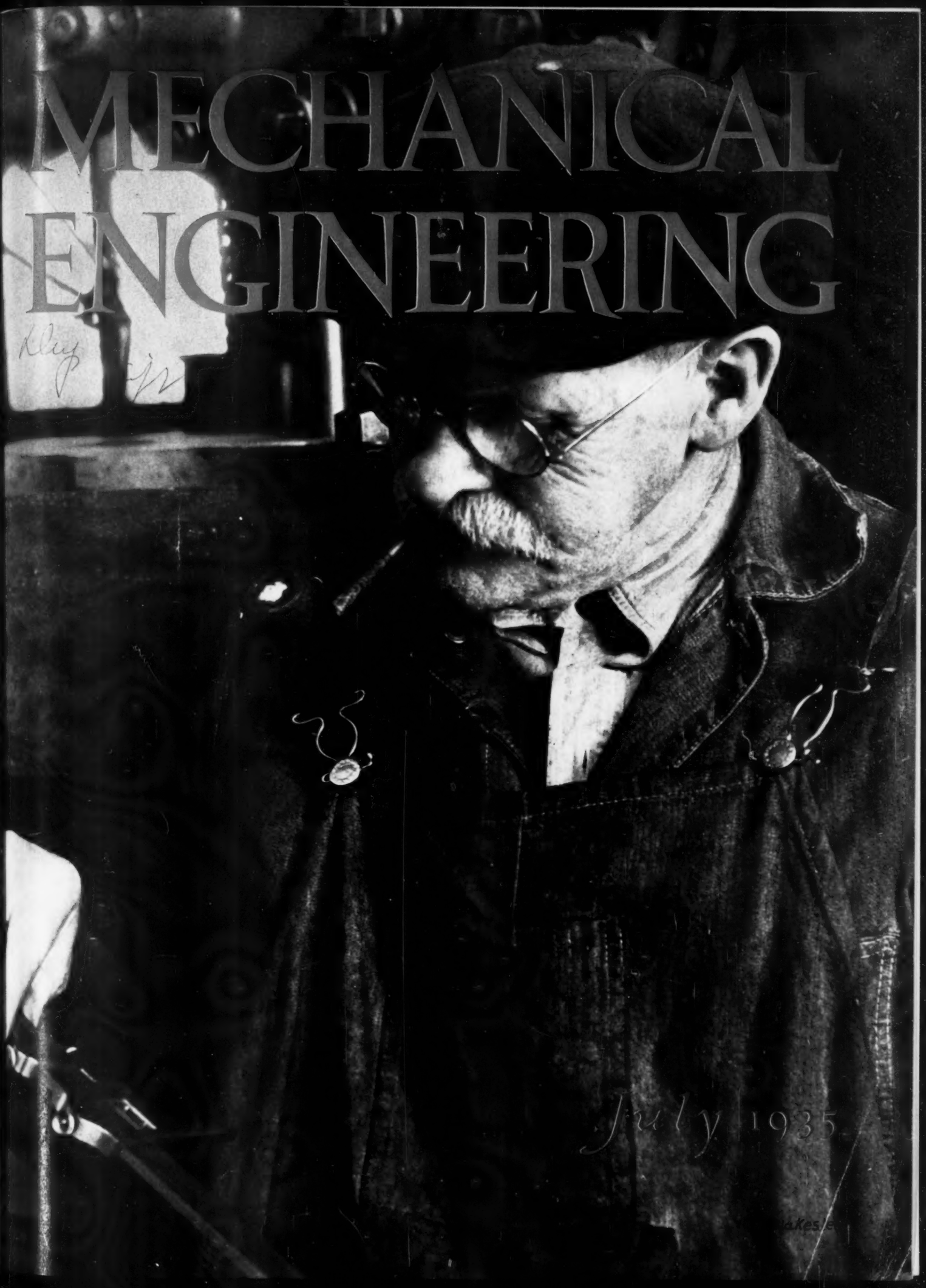
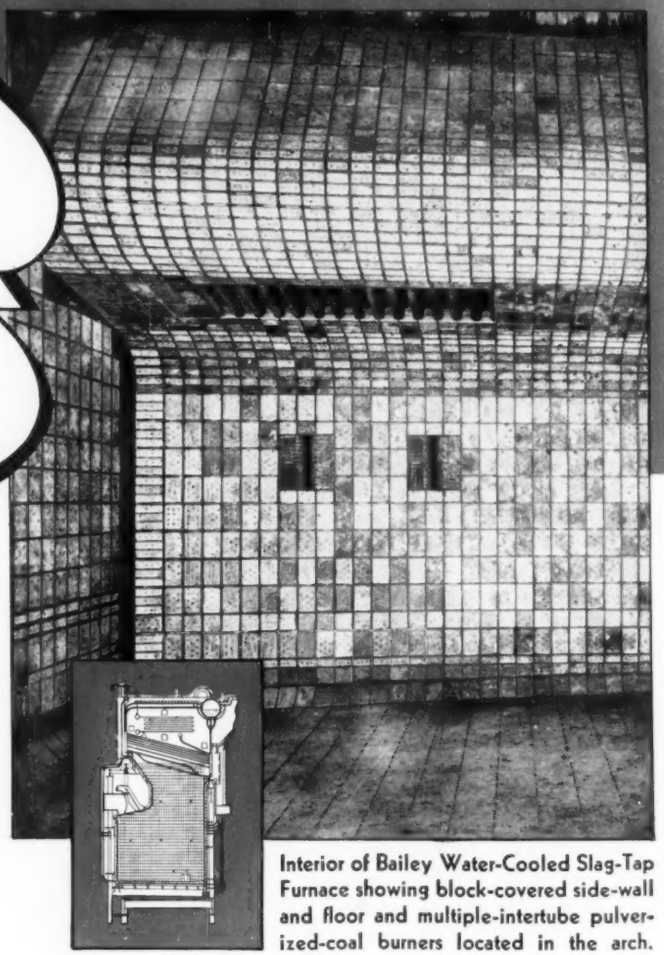
MECHANICAL ENGINEERING



July 1935

BAILEY WATER WALLS



Interior of Bailey Water-Cooled Slag-Tap Furnace showing block-covered side-wall and floor and multiple-intertube pulverized-coal burners located in the arch.

FOR BEST OVERALL PERFORMANCE

Coordination with other B&W Equipment makes possible a complete boiler unit capable of producing steam at lowest cost when all factors are considered.

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Operating records show furnace-availability as high as that of the best boilers.

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More than 750 installations throughout the world. In this country alone, under boilers having total output of over 92,000,000 pounds of steam per hour.

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Of interest to Industrial Plant Executives

WHAT'S NEW

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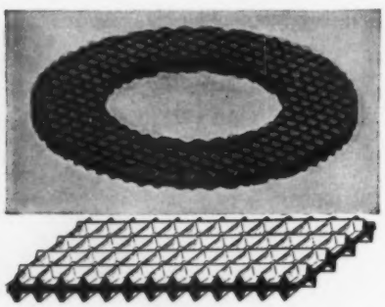
Metallic or Semi-metallic Gasket

The new Goetze Multiseal Gasket is designed to produce perfect tightness with only 30 per cent as much contact surface as on a



plain flat metal gasket, and with greatly reduced bolt pressure. This is accomplished by providing the faces with crossed ductile and resilient raised ribs, which under very small bolt pressure, set themselves into the tightest contact even on imperfect flange faces, and maintain the tightness perfectly under high fluid pressure, expansion and contraction and vibration. These gaskets are more resilient than flat solid metal gaskets, which if uneven in thickness or scratched on the surface require enormous bolt pressure and straining of the flanges to produce tightness. Inasmuch as making solid gasket metal uniform in thickness and keeping it free from surface nicks and scratches is almost impossible, the new Goetze Multiseal construction offers a simple and very effective means of producing and maintaining correct surface and thickness for dependable carefree service.

Goetze Multiseal Gaskets are obtainable as solid copper, steel, armco iron, aluminum or lead, as a metal shell with asbestos filler. Made in any circular, elliptical or special shape by Goetze Gasket & Packing Co., Inc., 34 Allen Ave., New Brunswick, N. J.

The Development of the Telephone

Recently the pagentry of telephone development was enacted in a radio broadcast. The discovery of the telephone, its development, and the heroic deeds associated with it were portrayed. The broadcast commemorated the 50th Anniversary of the American Telephone and Telegraph Co. and the 20th Anniversary of trans-continental telephone service.

Among the historic events dramatized was the first telephone call between Alexander Bell and his assistant, Thomas A. Watson, at Boston in 1876, and the first exhibition of the invention at the International Centennial Exhibition in Philadelphia the same year.

Walter S. Gifford, President, American Telephone and Telegraph Co. made an address, from which the following is quoted: "The American Telephone and Telegraph Company is 50 years old. It has become a great American Institution. ***Its nation-wide organization, existing in substantially the same form for half a century, makes possible telephone service as we know it today. A telephone call is so easy to make that the person making the call has no idea of the complicated physical equipment and the vast organization of workers behind it. ***It is the result of the free play of individual initiative and ability fostered and given free rein during all these years in an institution which recognizes the American ideal of equal opportunity for each individual to develop to the fullest his talents and personality. *** Instead of trying to prove that the possible couldn't be done, everyone was trying to see how the impossible—or what seemed impossible—could be and was done. It is this typical American spirit that assures our country getting out of its present difficulties. It is this spirit that has built up the Bell System, an institution that every minute of the day performs what 50 years ago would have seemed impossible miracles. *** We are celebrating one 50 years and looking into the next.

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Announcements accepted will be placed in the first available issue, space permitting. A given announcement may be inserted only once.

New York had seven telephone "centrals" in 1885

Reduced Maintenance Costs Assured by New Arc Welding Electrodes

Unusual interest has been shown in two new arc welding electrodes announced recently by the Lincoln Electric Company, Cleveland, Ohio. One of these electrodes, "Toolweld," permits savings up to 35% on tool costs while the other allows like savings in maintenance of equipment.

"Toolweld" electrode permits great savings by providing a cutting edge for metal and wood-working tools which is equivalent to high speed tool steel. Not only can tool steel tools be refaced innumerable times with "Toolweld," but new tools can be made at great savings by applying the electrode to alloy steel, which costs approximately 5-3/4 cents per pound compared with $.50–$2.00 per pound for tool steel. Tools so made have been shown by actual test to be equal to or better than average tools made of costly tool steel.

The metal deposited by "Toolweld" electrode is particularly suitable for tool work since it can be heat treated in the same manner as tool steel while possessing the additional advantage of retaining its hardness (55 to 65 Rockwell C) under relatively high temperatures, up to approximately 1000 degrees Fahrenheit.

"Abrasoweld" electrode is designed for building up straight-carbon steel, low alloy or high manganese steel surfaces to resist abrasion. Equipment resurfaced with "Abrasoweld" has been found to possess 50% longer life than was possible with other electrodes.

"Abrasoweld" is of particular value in such applications as restoring gear and pinion teeth; agricultural machinery; rock crushing equipment; housings and impellers of centrifugal sand pumps; lugs and treads of tractors; teeth, lips and bottom of power shovels.

Unlike other electrodes, the "Abrasoweld" deposit develops its maximum hardness (50 Rockwell C) only at the surface where it is cold worked. This leaves a strong tough core for resisting shock. Weld metal produced by "Abrasoweld" is more resistant to corrosion than high manganese steel and must be ground to shape as it cannot be filed or machined.

100-Pound High Pressure Barrel Pump

The new high pressure, air operated barrel pump introduced by the Alemite Corporation, 1822 Diversey Parkway, Chicago, Ill., converts any original 100-pound lubricant container into an efficient powergun for industrial lubrication. It develops a pressure 33 times the air pressure used and pumps eighteen ounces of regular lubricant a minute, a delivery more than sufficient to take care of several outlets at one time. This maroon, chrome plated barrel pump is provided with either a 4-wheeled truck for portability or a base for stationary installation.

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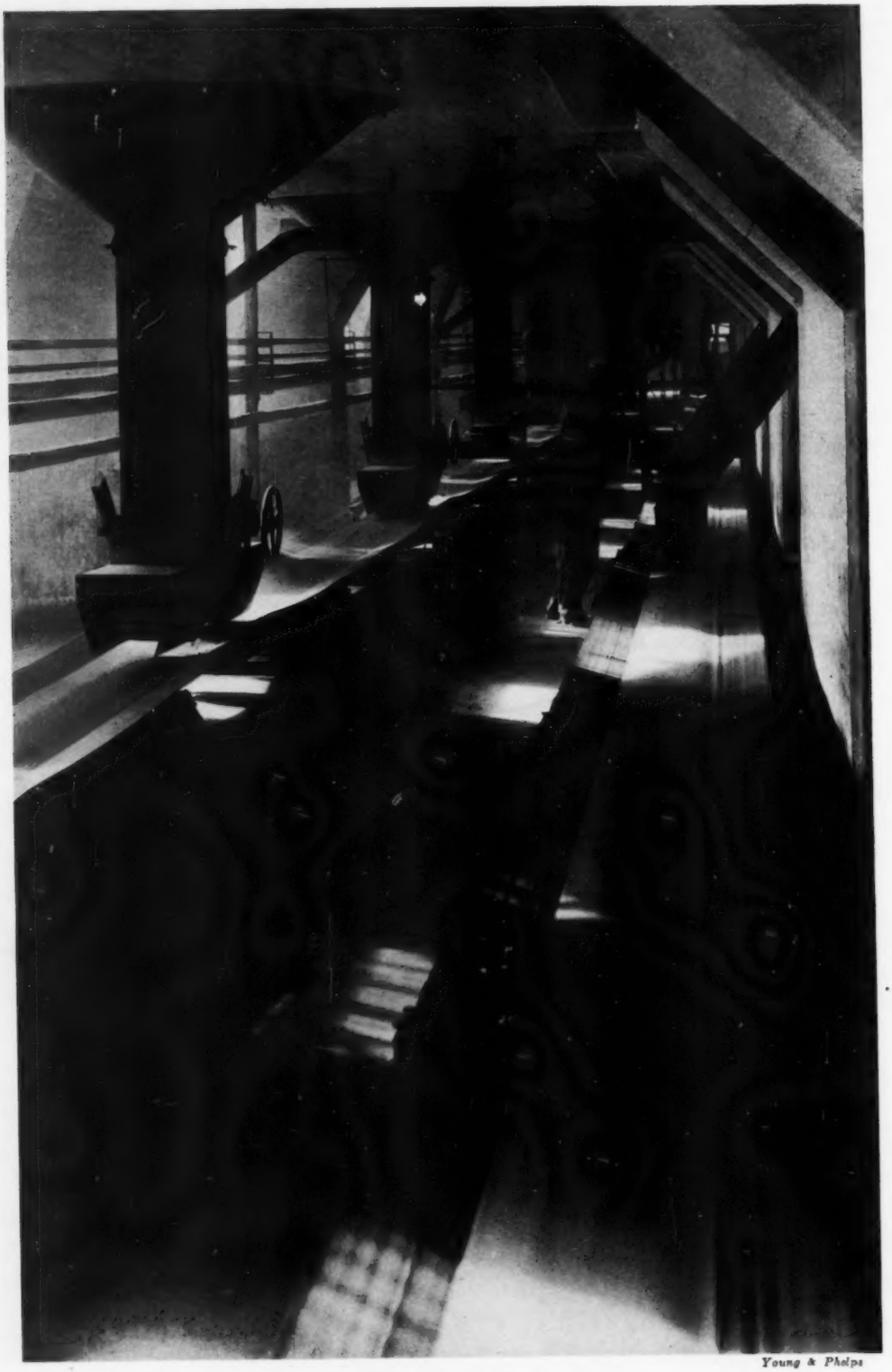


Young & Phelps

Grain in Transit

VOLUME 57
No. 7

MECHANICAL ENGINEERING

JULY
1935

GEORGE A. STETSON, *Editor*

The Pride of His Craft

IN A remarkable so-called "epitaph" written of himself by the colorful "Lawrence of Arabia," recently deceased, the reason for his renouncement of a life of letters and romance to become "Aircraftsman Shaw" is partially explained. After reciting the miscalculations of his financial provisions for a life of retirement—ending with his discovery, "My peace must be mixed with effort. Damn"—he says that "the conquest of the last element, the air, seems to me the only major task of our generation and I have convinced myself that progress today is not made by a single genius but by a common effort." Hence, he argues, it is the airmen mechanics who are overcoming the air. "Genius raids, but the common people occupy and possess."

Here is pride of craftsmanship articulate and ennobled. Here is a keen appreciation of that dependence which the machine has upon the man.

Elsewhere in this issue are papers presented at the Cincinnati Meeting of The American Society of Mechanical Engineers on apprenticeship training. That all young men undergoing such training might view themselves with respect to the machine as Shaw viewed himself would greatly strengthen that essential relationship between men and machines upon which our civilization depends. The depression has greatly depleted the ranks of those who are skilled craftsmen and mechanics. Were a reasonably normal return to capacity production to come suddenly, our greatest lack would be in trained man power. This fact must not be overlooked. We shall do well constantly to remember that "Genius raids, but the common people occupy and possess," and do everything in our power to train men to have Shaw's pride in his craft.

Professional Society Organization

WHENEVER engineers consider the number of agencies in this country devoted to their interests, their logical minds and their horror of waste and duplication lead them to think of schemes whereby unification and coordination may be brought about. In an article on the engineer and his societies published this month Professor Croft speaks of 90 national engineering societies. Mr. Feiker, of the American Engineering Council, has listed 277 national, state, and local organizations. Comparisons of this condition with that among physicians and lawyers, represented by the American Medical Association and the American Bar Association, are natural enough, although differences in the professions can be cited to show the hazards of such comparisons.

Engineers who have been close to the national societies are familiar with the history of their development, the reasons for the present apparent lack of coordination and unification, and some of the difficulties that would be involved in chucking the whole lot out of the window and starting afresh. They will be the last to deny the interest that attaches to all discussions of new societies, or new functions for old ones, or especially proposals for greater coordination and unification. In general their minds are open.

That engineering societies are working more closely side by side and finding ways in which their common interests join was strikingly illustrated in the meeting in New York on May 20 of the boards of the Founder Societies and the representatives of their joint functional agencies, reported this month in "What's Going On." Meetings such as this and discussions by engineers all over the country, in which the facts and principles involved in unifying the profession can be brought out, are most helpful. Professor Croft's article contains a proposal for a single engineering society. It is presented as an example of what some engineers are thinking about and in the hope of arousing interest in professional society organization. It represents Professor Croft's personal views. Others would be of interest.

Advertising for Professional Services

SELECTION of professional engineering services by competition in which financial considerations are paramount and sometimes the only ones, necessitating the bidding by one engineer against another, is a practice which professional engineering societies condemn for cogent reasons.. Neither the engineers who are, in certain cases, thus compelled to secure engagement, if they will have it at all, nor those who are desirous of retaining them, are well served; for the former there is a lowering of professional standards, while the latter may not get the talent they need and expect.

It is fair to say that in many cases such practices are followed by public authorities whose understanding of the professional point of view is slight and who ignorantly assume that professional services in engineer-

ing projects are impartially secured by such means. Inasmuch as public expenditures are greatly increasing and the services of engineers are being required by public bodies unfamiliar with professional engineering ethics, the Committee on the Manual of Practice of The American Society of Mechanical Engineers, which concerns itself with the practices of consulting engineers, has noted an increase in this method of engaging engineers and wishes to combat it vigorously. The American Society of Civil Engineers, in whose field such abuses are more common, adopted a resolution in 1925 condemning such competitive bidding and recommending that "public authorities and others desiring to secure professional engineering services select an engineer, from those available, on the basis of his qualifications, experience, and professional preparation for work of the size and character under consideration, determining by inquiry of recognized professional authority the appropriate basis of compensation for such services."

The Committee on Manual of Practice of the A.S.M.E. wishes to be informed of cases in which engineers are asked through advertisement or otherwise to submit in competition their terms for performing engineering services. Such information, addressed to the Secretary of the Society, will receive the prompt attention of the Committee, and will assist it in discouraging and stamping out this undesirable method of securing professional engineering services.

Biomechanical Repercussions

LAST winter we were privileged to meet Dr. Murray Gratz, of New York, whose studies in the field of orthopedic surgery led him to the adoption of engineering methods in biomechanical research. From certain engineers, notably G. B. Karelitz, member, The American Society of Mechanical Engineers, Doctor Gratz received valuable advice on the technique of materials testing and the interpretation of the results of his tests on fibrous body tissues. The engineering features of Doctor Gratz's work were published in MECHANICAL ENGINEERING for April, as an example of the manner in which workers in the professions of surgery and engineering had been of service to one another. Last month we attended a luncheon given by Doctor Gratz for the purpose of advancing interest in his research program, and we were pleased to learn that the notice accorded his article by engineers had been useful to him.

Speakers at the luncheon, at which the guest of honor was Dr. Arthur Steindler, of the State University of Iowa, confirmed the opinion, expressed by us in April, that such a rapprochement of the professions as Doctor Gratz had been able to effect was significant and an indication that the interchange of techniques could be made to serve the interests of all concerned.

The field in which Doctor Gratz is working is one of particular interest to industrialists with whom many engineers are in close contact as executives and personnel managers, because strains, sprains, and fractures are hazards to which workmen in many industries are constantly exposed. Whatever assistance can be given to orthopedists by engineers, whose familiar fields are those of mechanics and the strength of materials, may conceivably bear fruit when transplanted into the field of biomechanics, about which, apparently, too little is known. That the orthopedists appreciate the value of what the engineers have done for them was confirmed by Doctor Gratz's announcement that further work to be carried on by him and his co-workers would receive the scrutiny of experts in both professions before being made public. Such interchange of knowledge and help does credit to the good sense of both professions.

Double-Barrel Small-Caliber Guns

CONDITIONS of modern warfare call for light artillery of special types to support and protect infantry operations. This new type of artillery, of course, is to be supplementary to conventional types. The practical necessity for it arose with the development of trench warfare on the one hand and tanks on the other. What seems to be necessary is a gun that is as light as possible and yet capable of putting out of action a tank at a distance in excess of that at which the tank's offensive weapons are effective. It is also necessary to have a weapon that will permit a certain amount of high-angle fire at moderate distances and with a shell of moderate size, so as to be able to attack the objective from front-line trenches or emplacements where the regular artillery cannot be brought in.

Several solutions have been proposed. One which looked attractive, but did not prove quite practicable, was a gun carriage capable of mounting one of two tubes, the tube not mounted on the carriage being carried separately. Another solution, rather ingenious, was to insert a small tube inside a larger one when the former was to be used and withdraw it when the latter was called into action. An attempt has also been made to cast the two tubes in one piece. None of these attempts has proved satisfactory.

The famous Czechoslovakian armament works, Skoda, tried an arrangement in which both tubes were mounted on the same carriage, either side by side or one on top of the other. It was found unsatisfactory in firing, however, and aiming was practically impossible. It is now reported that the Bofors Company in Sweden, reputed to be controlled by foreign interests, has succeeded in producing a double-tube gun in which both tubes are mounted on the same carriage, one on top of the other. This gun is said to be free from the defects of the others. According to the information available the smaller tube has a bore of 37 mm, is intended for direct fire, chiefly as an anti-tank weapon, and has a range of 7300 m. The large tube, designed for high-angle fire, has a bore of 81 mm and a range of 5000 m. The total weight of the unit is 435 kg. The matter is important as the availability of such a weapon as this will materially affect the military usefulness of tanks.

STEAM *Versus* HYDRO POWER

A Discussion of Some Underlying Engineering and Economic Principles

By E. M. GILBERT

E. M. GILBERT ENGINEERING CORP., READING, PA.

IN OUR lives today electric energy is always available, and subconsciously we assume that it will always be ready to serve us without any special effort on our part. Lately, however, proposals to build some hydroelectric developments, together with public discussions of them, have made this question one of general interest; and at present many opinions based on snap judgment and without any conception of the essential details are being given on every side. It seems proper, therefore, to call attention to some facts well known to power engineers but, by reason of their intricate relationships, not so easily appreciated by the general public.

The wide distribution of relatively cheap sources of fuel throughout or adjacent to the industrial regions of the United States has made it possible to locate some sort of a steam plant almost anywhere. This has made steam power the real standard of reference by which the value of power is commonly rated. Also, because falling water is a free gift of nature, the public believes that water power is naturally cheaper than steam power, and should, therefore, be developed as fast as a market for it appears, especially as this would conserve the country's fuel resources for future generations. This popular opinion has been rather confirmed ever since the advent of electric power transmission by the apparent eagerness of capitalists to invest money in the development of hydro power. Bonds on a "white-coal" project have always been marketable.

LOCATION OF AVAILABLE HYDRO POWER GENERALLY UNFAVORABLE

The development of this country has exercised a definite influence on this situation. The pioneers, naturally, settled along the river banks, as these streams afforded the best and, in fact, the only means of transportation. Later, as the inventive and commercial instincts of these settlers developed, these streams in addition furnished a source of power for grist and saw mills and early manufacturing plants. As improved forms of transportation, canals, highroads, and finally the railroads were developed, they too were built along these same river banks, first, because these were in most cases the easiest and cheapest routes and, second, because these routes would reach the largest centers of population from which these new developments must derive their support. Population and manufacturing follow the railroads, and as a result most of the great centers of industry are located along the rivers.

In a thickly settled country such as the eastern half of the United States, any possibilities of creating new large-scale water-power developments are badly complicated by the necessity for displacing the railways and highways. These are already in river valleys that might otherwise be available for storage reservoirs, even though the locations were at a considerable distance from the industrial centers and in districts only sparsely inhabited. The expense of these changes would have to be added directly to the fixed charges against the cost of construction. All sites capable of easy and economical development have already been used, and if it were not for the fact that high-tension transmisson has made it possible to develop power at a considerable distance from the power market, large hydro development, at the present time, would be practically at a standstill.

As an added commentary on this situation it should be noticed that while 70 per cent of the total market for power is located east of the Mississippi, 72 per cent of the water-power resources are to the west of that river.

An economic hydro development depends almost entirely upon its first cost and the continuity of the power that can be furnished by the river supplying the water.

CONTINUITY OF STREAM FLOW IMPORTANT IN HYDRO POWER

Not long ago it was usual to regard both hydro and steam-power developments as applicable to markets only in their near vicinity. Then the important consideration for water power was whether the minimum flow of stream would suffice to carry the expected load, and the plant was developed at or near this capacity. Two results followed: (1) A waste of water over the dam whenever the stream flow exceeded this capacity, and, (2) a shortage of power as the load grew with industrial development, which necessitated either an auxiliary steam plant or reservoir storage if continuous or firm power, and sometimes both, were required.

Looked at from another angle, the cost of constructing the hydroelectric plant itself generally represents only a portion of the total expenditure necessary to furnish firm or steady power to the consumer. As a practical example, the York Haven development on the Susquehanna River operates as a stream-flow plant, and during dry seasons it develops only 4000 kw of the complete 20,000 kw installed. In order to make this 20,000 kw available for use whenever and as the consumer needs it, it would be necessary to build an additional 16,000-kw steam plant or a storage reservoir, and the cost of the addition would have to be included against the hydro development. A transmission line is also necessary to market the power.

In fact, the outstanding characteristic of a hydro development having limited storage or none at all is the enormous disparity between minimum and maximum flow and also between average and maximum. The peak load of a utility plant comes on each day at certain well-defined hours, and the daily load curve of any utility is quite definite throughout each day without radical changes from season to season of the year. But, while the flow of a stream does not change quickly from hour to hour, it is subject to tremendous variations with the seasons, and with no relation whatever to the load curve of any public utility.

On the other hand, in the case of steam, the supply up to the peak demand capacity of the plant is always available for carrying the demand whenever it is called for.

Condensed from an address at Reading, Pa., February 14, 1935, before the Anthracite—Lehigh Valley Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

EFFICIENCY OF HYDRO PLANTS PRACTICALLY AT A MAXIMUM

The use of water in the wheels of a hydro plant is within fixed limits of efficiency that vary with head and load. Refinements of design can only alter the overall efficiency of a hydro plant in a very small degree; they cannot alter the head nor the stream flow. About the only recent development that enables changes of head to be compensated for to any extent is the Kaplan adjustable-propeller type of turbine which has recently come into use.

The efficiencies of hydro developments have now apparently

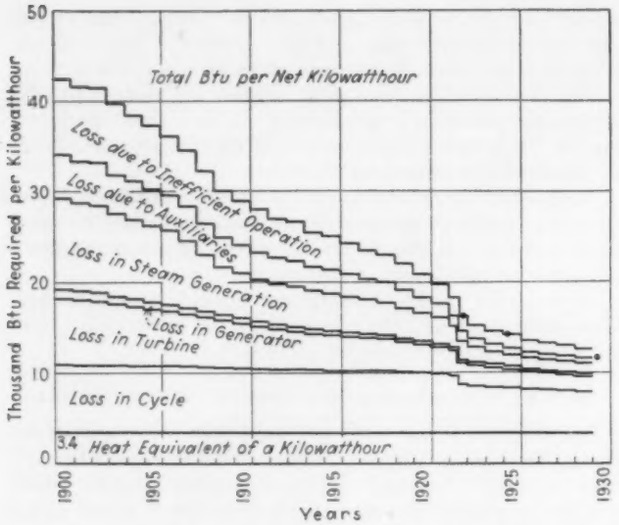


FIG. 1 REDUCTION IN HEAT CONSUMPTION IN POWER GENERATION, 1900–1929

reached a point beyond which any large future improvement is at least doubtful. At the most efficient point modern wheels obtain an efficiency of 94 per cent and the generators 97 per cent, while a fair average for wheel efficiency is 85 per cent and for the generator 93 per cent.

It is but natural that during the years of growth in the hydroelectric field, the sites most accessible to the market and capable of development with least expense should be utilized first, with the result that the cost of development, including transmission to the market, is continually increasing.

Even in the case of an existing transmission network to which it is proposed to add a new hydro or steam project, this network has already cost money, the fixed charges on which should be included in the total cost of power from new sources as well as old.

In other words, we have now reached a point where the efficiency of conversion and transmission of water power is advancing very slowly, if at all, and where the cost of utilizing it will continue to increase.

PROGRESS STILL BEING MADE IN EFFICIENCY OF STEAM PLANTS

In the meantime great advances have been made in the practical use of the economic possibilities of the steam cycle, especially in plants of the largest size. Reduction in heat consumption and improvement in efficiency in power generation from 1900 to 1929 are shown in Figs. 1 and 2.

With the steam plant the operating cost per kilowatthour generated depends primarily upon the grade and the price of the fuel and also upon the average output of each generating unit, that is, upon the load factor at which each machine operates. Fuel cost is the chief variable; the other operating costs of labor, supplies, and maintenance are, for purposes of comparison, practically determined by the size and design of the plant and can be treated as a fixed amount per year more or less independent of the kilowatthours generated. The fuel rate per kilowatthour has been cut down tremendously during the past fifteen years as shown in Fig. 3. In 1919 the average fuel rate for all the public-utility steam plants in the United States was 3.2 lb of coal per kwhr. By 1924 this had been cut to 2.2 lb, and by 1929 to 1.69 lb. In 1933 it was estimated to have been 1.48 lb for the country as a whole, covering all types and sizes of steam stations, old and new. Assuming that the average coal burned in public-utility stations throughout the country has a heat value of 13,000 Btu per lb, the heat rate for 1919 per kwhr would be 41,600 Btu, and for 1933 it would be 19,250 Btu.

These figures are, of course, only averages for the whole country and do not show the maximum advances made at the most highly developed steam plants. There are now many plants with coal rates below 16,000 Btu per kwhr year in and year out. A low rate of slightly less than 12,000 Btu was

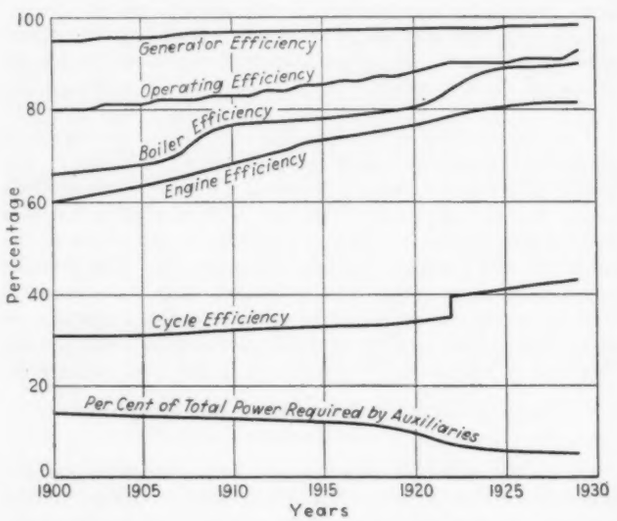


FIG. 2 IMPROVEMENT IN EFFICIENCIES IN POWER GENERATION, 1900–1929

obtained by the Gilbert plant at Holland, N. J., in 1930 and also in a steam plant at Deepwater, N. J.

This progress from 1919 to 1933 in the case of the Pennsylvania-New Jersey group of utilities is shown in Table 1.

TABLE 1 PROGRESS IN STEAM-POWER-PLANT ECONOMY, 1919–1933

Plant	Throttle pressure, lb per sq in.	Year	Btu per net kwhr	Coal, lb per net kwhr	Overall thermal efficiency, per cent
West Reading	190	1919	29,510	2.16	11.54
West Reading	250	1924	19,380	1.39	16.41
Middletown	325	1925	15,711	1.138	21.72
Gilbert	1250	1933	11,960	0.864	28.55

New developments are rapidly coming to the fore that will continue to reduce the cost of steam generation. Foremost among these should be mentioned the use of higher superheats and pressures, and the use of mercury-vapor turbines. Both have been experimented with and are gradually coming into use. The limits to which steam temperatures can be raised is mostly a metallurgical problem at the present moment and is

gradually being solved. Mercury turbines in operation have shown coal production costs as low as 0.65 lb or 8500 Btu for regular operation year in and year out. The highest thermal efficiency reached in the modern steam plants is below 35 per cent, which leaves a tremendous amount of leeway for future development.

CONSTRUCTION COSTS COMPARED

The construction cost of steam plants is also coming down rapidly. Ten years ago the most efficient plants cost anywhere from $140 to $180 per kw, while today an economical steam plant of large capacity and with high pressures can be built

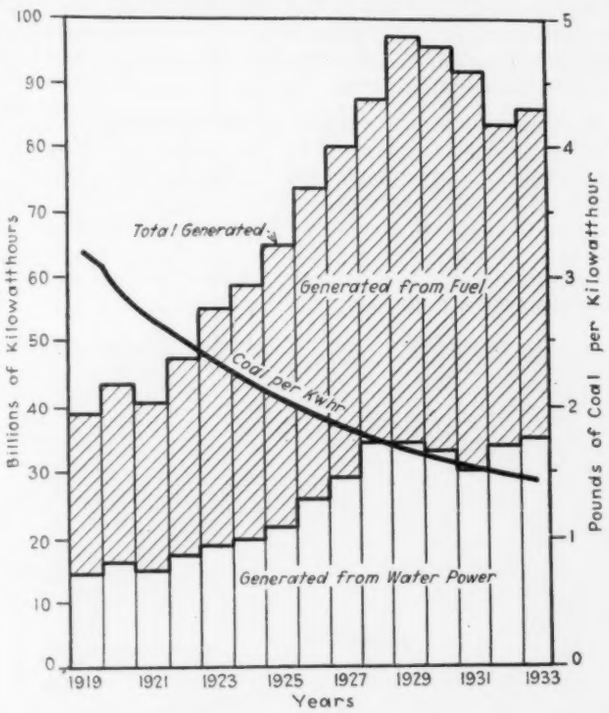


FIG. 3 CENTRAL-STATION OUTPUT FROM FUEL AND WATER POWER, AND EFFICIENCY OF THERMAL PLANTS

for under $100 per kw, and those using pressures around 300 lb can be produced for $80 per kw, with the increment costs of additions to the plant down as low as $60.

The location and construction cost of a hydro plant is fixed by the peculiar characteristics of the power site. Under existing conditions this is generally distant from the market and, if so, it will require a high-tension transmission line with step-down substations at the various power markets. Each project will vary as to the possibility, and the cost, of water storage and the amount of steam auxiliary required to supply the market demand when called for in season or out of season.

Without storage the amount of power available depends entirely upon the seasonal rainfall and may vary to 70 to 80 per cent below the installed capacity.

The total investment includes the cost of water rights, land rights, dams, head and tail races, storage development, and removal of existing property on the land that is to be overflowed, also auxiliary steam reserve and transmission necessary for marketing. These items are different for every power site and condition. The aggregate cost of all these items must be paid whether the hydro plant is to contain one or a dozen or more generating units.

OPERATING COSTS COMPARED

Although its actual operating cost from day to day is relatively very small, the fixed charges upon an investment necessarily heavy from the very start constitute the real operating expenses of a hydro plant. Once established, they are, for a plant of given size, thereafter independent of either stream flow or of any mitigating circumstances other than amortization from earnings.

A steam plant can be put at any location to which fuel can be transported. A condensing steam plant, which is required for a minimum fuel consumption, can be located wherever there is a suitable supply of condensing water. The cost of steam-power production is easily predictable for any given set of conditions of fuel cost and load factor almost irrespective of location. Therefore the plant can be placed near the centers of load, saving in most cases the cost of transmission. All the capacity of a steam plant can be utilized at will up to the full capacity installed, at any time the load demand may call for it, regardless of time of day or season of the year. It needs no outside help and generally the total investment is covered by the cost of the plant alone, although sometimes a small transmission expense is necessary.

One important consideration in comparing the construction of hydro and steam plants is that a steam plant can be built successfully under increment conditions, or really on the instalment plan. If the load growth were such as to require 100,000 kw increase in capacity during a five-year period of time, this need not all be installed at one time. Each unit would be put in operation as the growth demanded it and not before, and the total investment spread over the full period, with a very great reduction in fixed charges for the full five years. On the other hand, probably 75 to 80 per cent of the total expenditure in a hydro plant goes into permanent works which must be built at one time irrespective of the number of units installed, and, faced with this condition, engineers often find that the installation of the machinery necessary for the full development will pay as the surplus power developed, having little fixed charge against it, can be produced at less than the coal cost on some of the lesser steam plants. In other words, with the hydro plant, fixed charges for the complete plant will have to be paid from the date of the first installation.

This method of construction of a steam plant eases the difficulties of financing, as only a small amount of money is required at a time, and materially reduces the fixed charges against generation.

FIXED CHARGES COMPARED

By fixed charges on any project is ordinarily meant the sum of interest, taxes, insurance, and depreciation, all of which depend directly upon investment cost. Certain operating expenses, such as superintendence, labor, supplies, and maintenance, which vary more with the capacity of the plant than with its output, can also be rated as fixed charges and reckoned along with the financial charges just mentioned. The entire cost of hydro operation is really a fixed charge.

Authorities differ on the rate for financial fixed charges. It is usual to charge from 6 to 7 per cent for the money, 2 per cent for taxes at present, and $1/2$ per cent for insurance. This applies to both hydro and steam plants. The depreciation varies considerably. With a hydro plant there is little depreciation on the permanent works, and generally 1 to $1\,1/2$ per cent over the whole investment is sufficient. With the steam plant a majority of the money is spent for machinery and depreciation is 4 to 5 per cent.

In either a steam or hydro plant, the operating expenses

include a practically fixed annual sum determined by the kilowatt capacity of the plant. In the case of a steam plant they also include an amount of fuel directly dependent upon the quantity of energy generated per year. This fuel item is governed by the load factor which determines the proportion of time that the generating equipment is utilized and this is of particular importance in the case of steam power because the plant load factor, or capacity use factor, directly affects the rate of fuel consumption and the fuel increment cost of producing kilowatt hours in varying quantities.

SUMMARY

Summarizing briefly the foregoing it will be found that:

(1) A hydro plant has a variable power supply unless expensive storage or auxiliary steam plant is included.

(2) It has practically attained maximum efficiency in design.

(3) The cost of construction is continually increasing.

(4) The location of the plant is fixed by the site and under existing conditions it is generally a long way from the market, requiring added transmission costs.

(5) The initial cost of construction is largely for permanent works and consequently increment construction generally does not pay.

(6) Practically all charges against generation are definitely fixed.

(7) A steam plant may be located almost anywhere, and, consequently, is close to the market, requiring little, if any, transmission expense.

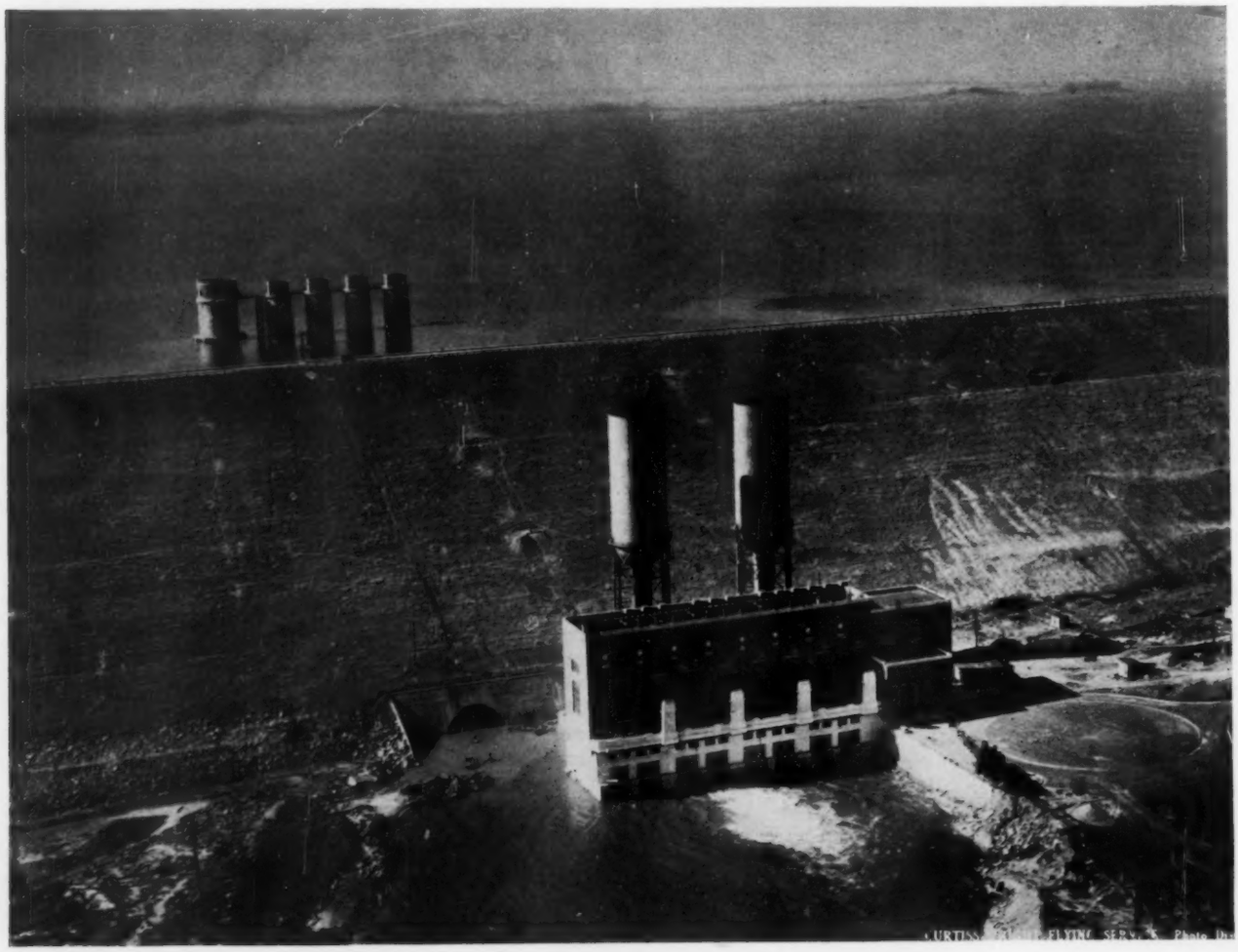
(8) The cost of generation with steam is being continually reduced and has not by any means reached its minimum.

(9) The cost of construction of the steam plant is being continually reduced.

(10) The full capacity of the plant is available at any time when and as the consumer needs it.

(11) The steam plant can be built on an increment basis, saving much in fixed charges and difficulty of financing. As the cost of investment per kilowatt does not change much with change of location, the capacity required can also be divided, if advisable, and placed at the best location.

In reading this summary it will be seen how difficult it is to compare these developments. No two hydros producing the same amount of current can be built for the same costs, and generally the variation in cost is extreme. The distance from the market, the question of storage, the question of foundation, the size of the dam, the rainfall, the run-off, and the head, all affect the cost. It would seem also that the conditions are generally adverse to the hydro development.



POWER HOUSE AND INTAKE TUNNELS, SALUDA (S. C.) POWER PLANT

(In hydroelectric plants a majority of the construction consists of permanent works, and the addition of generating equipment is a small factor in total cost.)

Some Aspects of the TURBULENCE PROBLEM

By TH. VON KÁRMÁN

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THE application of rational hydrodynamics to technical problems is handicapped by the fact that in most cases the apparently steady motion of fluids is only steady in so far as the temporal mean values of the velocities and the pressure are concerned; in reality velocities and pressure are subjected to irregular fluctuations. For such a type of motion the term "turbulent" is applied. In all such cases the velocity and pressure distribution, and especially the energy losses, are determined mainly by the turbulent fluctuation, so that for technical hydrodynamics a real theoretical foundation is possible only on the basis of an understanding of the turbulent motion.

In the development of our knowledge of technical hydrodynamics, three periods are clearly distinguishable:

In the first period the discrepancy between streamline flow and the flow generally observed in conduits and rivers was realized; but in the lack of a rational basis for understanding turbulent flow, only some quite general conceptions of the theory—such as the energy and momentum laws—were used, and everything else determined by *ad hoc* experiments and empirical laws deduced from these experiments.

The main purpose of the research in this period of empirical science is the evaluation of constants for equations, whose forms are given by some simple momentum or energy considerations. Of course, due to the complexity of the phenomena, most of these constants were valid only in certain rather narrow ranges. This period may be called one of "variable constants."

When a little more than half a century ago Osborne Reynolds discovered the laws of the instability of streamline motion and the fundamental facts of turbulent flow, this situation changed so far that application of the principle of dimensional analysis facilitated the systematic evaluation of experiments and the transfer of data from one case to another. We learned how to compare experiments carried out on water, oil, and air, and the laws for extrapolation from model to full scale. In this second period the "variable constant" was replaced by a function, in most cases a function of a certain dimensionless parameter, whose magnitude gives the ratio between viscous and inertia forces. The choice of this parameter depends, of course, on the special problem; however, it is invariably of the same form connecting a characteristic velocity and a characteristic length with the kinematic viscosity of the fluid concerned. This parameter is often called the Reynolds number.

In spite of the fact that the ideas of Reynolds are not yet spread out over the whole field of the technical applications, we are at the beginning of a third period, with even more ambitious aims. Dimensional analysis gives a frame in which to systematize the empirical facts, reduces the number of necessary tests, but does not say anything about the particular shape of the curves and functions which are replacing the variable coefficients of the first period. This obviously depends on the mechanism of the turbulent motion, and the chief ambition of the modern "turbulence research" is to find out as much as possible about the laws which actually govern the turbulent motion, possibly so much that velocity and pressure distribution, energy transfer, and energy loss can be computed without any or with a minimum of empirical elements, as is possible in the case of perfect fluids or in the case of the streamline (laminar) motion of viscous fluids.

Certainly we are just at the beginning of this development, and it is hard to see whether one or two or more generations of scientists and engineers will have to work on the problem until a definite success is attained. However, it seems to me to be worth while to review the extent of our present knowledge, and especially to review the practical problems connected with this research which may be enlightened by new knowledge in this field.

Fluid motion can be analyzed from two different points of view: The so-called *Eulerian* method considers pressure and velocity at a given point, and the *Lagrangian* method describes the fate of an individual fluid particle. From the viewpoint of the Eulerian method, turbulent flow is described by the fluctuations of velocity and pressure at fixed points. The first characteristic feature of these fluctuations is their irregularity, i.e., the absence of any definite frequency, while the presence of definite frequencies is, for instance, characteristic of a wave motion. Resonance instruments responding to a certain frequency, while sensitive to much smaller regular velocity fluctuations than those occurring in a turbulent stream, fail to show any response. However, there is, in general, a statistical correlation between the components of the velocity fluctuation, e.g., between the fluctuations in the direction of the main flow and the components perpendicular to this direction, or between the fluctuations in the magnitude and in the direction of the velocity vector. It is easy to see that without such a correlation no tangential force (shearing stress) could be transmitted through a plane which is parallel to the direction of the main flow except by laminar friction. Consider the x-y plane and assume that the main flow is in the x-direction. If at a certain point and at a certain moment the velocity has a positive component w' in the z-direction, a fluid particle leaves the region below the x-y plane; every such particle with the mass m having a velocity $U + u'$ (U being the main velocity, and u' the velocity fluctuation in the x-direction) represents a momentum in the x-direction equal to $m(U + u')$.

The momentum corresponding to the particles passing through the x-y plane in unit time obviously gives the reaction of these particles on the portion of the fluid below the x-y planes; every particle leaving the region with a negative velocity contributes a force in the positive direction. Inversely, particles entering through the x-y plane, i.e., having negative w' components, represent a contribution to the force acting on the fluid below the x-y plane with the same sign as the u velocity of the particles concerned. The combinations $(+w')$ and $(-u')$, $(-w')$ and $(+u')$ represent contributions to a positive shearing force; the contribution of the main velocity U drops out since, due to the continuity, the total mass of the particles passing in both directions must be equal. Consider the force

acting on a unit area of the x-y plane. The mass of the fluid passing through a unit cross-section in unit time is $\rho w'$. Due to the aforementioned relation between w' and u', during the period between the time $t = 0$ and $t = T$, the average "momentum transfer" per unit time will be $\frac{1}{T}\int_0^T (-\rho u'w')dt$ or $-\rho\overline{u'w'}$ (mean value of $-\rho u'w'$). This quantity represents the tangential force per unit area, i.e., the "shearing stress" τ_{zx}. We call this quantity the "apparent or turbulent friction." It appears fully justified to call this quantity a stress or a friction, because the viscous or laminar friction has a quite similar origin. It represents the momentum transferred by the molecules which are agitated by the thermal unrest. Thus, in the case of parallel mean motion, the total amount of the internal "friction," due to viscosity and turbulence, will be (neglecting variations of the density ρ)

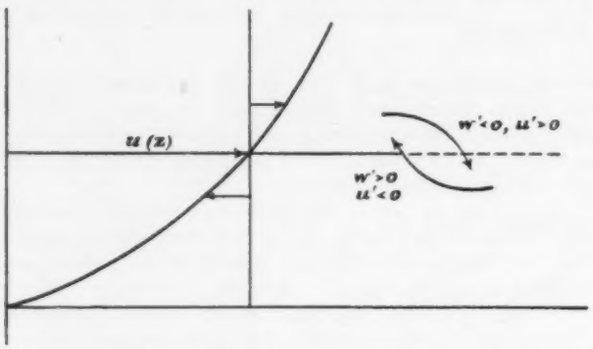


FIG. 1 TURBULENT EXCHANGE OF MOMENTUM

$$\tau_{zx} = \mu \frac{\partial \bar{U}}{\partial z} - \rho\overline{u'w'} \quad \ldots\ldots\ldots\ldots\ldots [1]$$

where the first terms indicate the laminar friction and the second the turbulent friction. In order to calculate the laminar friction, it is sufficient to take into account the slope of the mean velocity $\bar{U}$ because the contribution of the fluctuations is in mean value equal to zero.

It will be noticed that:

(*a*) The turbulent friction is different from zero only if there is a correlation between the perpendicular velocity components. If there is no correlation, i.e., if the fluctuations are completely independent, the $\overline{u'w'}$ is zero.

(*b*) At a solid wall the turbulent friction is zero because the velocity components vanish. It is found experimentally that in the immediate neighborhood of a wall streamline motion is likely to exist. This region is called "the laminar sublayer."

(*c*) In general, from the experimental facts for high Reynolds' numbers, except in this laminar sublayer, $\mu \frac{d\bar{U}}{dz}$ is small in comparison with τ_{zx} and consequently with $\rho\overline{u'w'}$; so that we may neglect the laminar friction and put

$$\tau_{zx} = -\rho\overline{u'w'}$$

Furthermore, it is easy to conclude from the foregoing reasoning that if the density or the temperature, or the concentration, of certain foreign material in the fluid (solution, suspension, etc.) is subjected to fluctuations, the transfer of mass, of heat, or of the concentration can be expressed analogously to the transfer of momentum. For instance, if θ' denotes the fluctuation of the temperature, and c is the specific heat of the fluid, $-c\overline{\theta'w'}$ represents the flow of heat per unit area of the x-y plane. Similarly, $-\overline{\rho'w'}$ represents the mass transfer (ρ' is the density fluctuation), and $-\overline{n'w'}$ the number of particles transferred through the same cross-section, provided that n is the number of particles carried per unit volume and n' is the fluctuation of n.

It is concluded that intensive turbulence must cause an increase of all transfer phenomena, such as heat conduction, diffusion, and sediment transportation.

Looking at the same phenomenon from the Lagrangian viewpoint, a continuous intermingling or mixing of particles is observed instead of the velocity fluctuations at a certain point. Prof. C. M. Allen[1] recently compared the fluid in turbulent flow with a flock of sheep. This comparison is illustrative, but the simple fact of intermingling does not explain the main feature of the turbulent flow, namely, the turbulent interchange of quantities already mentioned, such as momentum and heat. We have to assume that, due to the intermingling, a particle loses its excess of velocity or temperature after covering a certain distance, i.e., it accommodates itself to the new surroundings. Otherwise no transfer of momentum or heat would be possible. This leads to the assumption of a certain path of convection or "mixing length" as it is called by Dr. L. Prandtl, who transferred the concept of the "mean free path" of the molecular theory into the theory of turbulence. This concept allows a new and different formulation of the expression for the turbulent shearing stress or friction. Combining the two viewpoints, it is apparent that at a certain point particles coming from regions of lower mean velocity will be registered mostly as contributing negative amounts to the velocity component in the x-direction, while particles coming from regions where the mean velocity U is higher will produce a positive amount of the u' fluctuation. Thus we see the physical origin of the correlation; and introducing the conception of the mixing length l, defined as the average distance perpendicular to the main flow, covered by the mixing particle, it appears to be justifiable to put u' proportional to $l\frac{d\bar{U}}{dz}$, i.e., to the difference in mean velocity between the region where the particle started its wandering and the point where the fluctuations are registered.

Hence

$$\tau_{zx} = \beta\rho|w'|l\frac{d\bar{U}}{dz} \quad \ldots\ldots\ldots\ldots\ldots [2]$$

where $|w'|$ is the absolute average amount of the fluctuation perpendicular to the flow and β is a numerical coefficient introduced as a measure for the correlation between the velocity components. To be sure, β, $|w'|$, and l can, and in general will, vary from point to point. In a similar way, we can write the turbulent heat transfer

$$-q = \beta c_p|w'|l\frac{d\bar{\theta}}{dz} \quad \ldots\ldots\ldots\ldots\ldots [3]$$

and the number of suspended particles transferred per unit area and time

$$-N = \beta|w'|l\frac{d\bar{n}}{dz} \quad \ldots\ldots\ldots\ldots\ldots [4]$$

Obviously it is subject to further discussion as to whether the quantities β, $|w'|$, and l are the same in Equations [2], [3], and [4].

Equation [2] contains many unknown quantities: β, $|w'|$,

[1] "How Water Flows in a Pipe Line," by Charles M. Allen, MECHANICAL ENGINEERING, February, 1934, pp. 81–84.

and l. Prandtl suggested putting $|w'| = l\left|\frac{dU}{dz}\right|$ and absorbing the correlation coefficient β in l^2. Thus we obtain

$$\tau_{xz} = \rho l^2 \left|\frac{dU}{dz}\right| \frac{dU}{dz} \quad \ldots\ldots\ldots\ldots\ldots\ldots [5]$$

However, this is only a formal simplification as we concentrate all unknown elements into the mixing length l. It seems to the author that Equation [5] has a real physical sense only if the correlation is the same in all points of the fluid considered. In other words the mechanism of the turbulent friction can be fully characterized by a single length l only in case the flow pattern in the neighborhood of every point is similar, differing only in scale both as far as time and length are concerned. This is the hypothesis introduced by the author in his paper

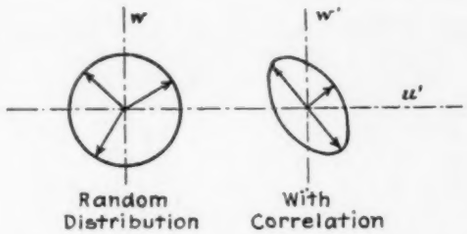


FIG. 2 DIAGRAM OF VELOCITY FLUCTUATIONS

on "Mechanical Similarity and Turbulence,"[2] published in 1930, and which led him to the theoretical conclusions given in this paper. Most of the results of these calculations are in good agreement with the experimental facts.

On the other hand, Equations [2] to [4] formulate the problems which we have to face in order to obtain a complete theory of the turbulent flow. How l, $|w'|$, and β depend on curvature, divergence, and convergence of the flow, and on the distribution of density, is obviously a basic problem, which, investigated experimentally and theoretically, may give the possibility of a treatise of turbulent flow under any given conditions. The importance of these questions for many different fields is obvious, e.g., hydraulics, aeronautics, meteorology, hydrology, and oceanography. At the present time we are at the beginning of this research, but valuable information is already available as far as some simple cases are concerned. In what follows, some of these applications are briefly reviewed.

The pressure drop per unit length in a closed conduit is given by

$$-\frac{dp}{dx} = \lambda \frac{1}{m} \rho \frac{V^2}{2}$$

where $m = \frac{A}{P}$ is the hydraulic radius, A is the cross-section, P is the perimeter, and V the average velocity. Obviously the equation for the equilibrium between surface friction τ_0 and pressure drop can be written

$$\tau_0 P = -\frac{dp}{dx} A$$

which results in

$$\tau_0 = \lambda\rho \frac{V^2}{2} \quad \ldots\ldots\ldots\ldots\ldots\ldots [5a]$$

[2] Proceedings of the Third International Congress of Applied Mechanics, Stockholm, 1930.

Hence λ has the meaning of a "friction coefficient" referred to the mean velocity V. We sometimes introduce a friction coefficient λ' referred to the maximum velocity V_{max}, putting $\tau = \lambda'\rho V^2_{max}/2$.

λ and λ' are functions of the Reynolds number $R = Vm/\nu$ as far as pipes with similar cross-sections are concerned. Sometimes they are assumed to be independent of the shape of the cross-section. This is not exactly true, but the influence of the shape is not very significant.

A vast number of empirical formulas have been suggested for the relation $-\lambda$ vs R. The aim of a rational turbulent theory is to establish a theoretically correct, or at least justified, form of this relation.

Dealing at first with smooth-walled pipes, we divide the flow into three regions:

(*a*) In the immediate neighborhood of the walls, laminar flow is assumed and the shearing stress is equal to μ times the perpendicular slope of the velocity (laminar sublayer).

(*b*) Outside of this laminar sublayer turbulent flow is assumed over the whole cross-section, and the laminar friction is neglected.

Let us consider a pipe with circular cross-section or with rectangular cross-section of large aspect ratio (flow between two parallel walls). In this case no secondary motion occurs and the conditions are rather simple. Using the basic assumptions on turbulent flow already presented, we obtain two results verified by the experiments:

(1) The velocity distribution in the center section of a tube is given by a universal relation

$$\frac{u_{max} - u}{\sqrt{(\tau_0/\rho)}} = f(\eta/r) \quad \ldots\ldots\ldots\ldots\ldots\ldots [6]$$

where u_{max} is the velocity in the center, η the distance from the center, r the radius of the cross-section (half distance between the plates, respectively), and $f(\eta/r)$ is a given function for all pipes with circular cross-section and a slightly different function in the two-dimensional case.

(2) The velocity distribution near the wall is given by a second universal relation (y = distance from the wall)

$$\frac{u}{\sqrt{(\tau_0/\rho)}} = g\left(\frac{y\sqrt{(\tau_0/\rho)}}{\nu}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots [7]$$

The quantity ν/y has the dimension of a velocity, thus the quantity $y\sqrt{(\tau_0/\rho)}/\nu$ is a dimensionless ratio. We find that the thickness δ_l of the laminar sublayer is proportional $\nu/\sqrt{(\tau_0/\rho)}$; hence $y\sqrt{(\tau_0/\rho)}/\nu$ is proportional to the ratio between the distance y from the wall and the thickness of the laminar sublayer δ_l.

Equation [6] is independent of the viscosity (or Reynolds' number), while in Equation [7] the viscosity explicitly occurs. This is easily understood, realizing that in the center of the pipe the viscous forces are negligible in comparison with the turbulent friction; therefore, the development starting from the center is independent of the viscosity. The development starting from the wall can be written in the form

$$\frac{u}{\sqrt{(\tau_0/\rho)}} = g\left(\frac{y}{\delta_l}\right)$$

and so it contains the viscosity coefficient, because the thickness of the laminar sublayer obviously depends on it.

We call the function $g\left(\frac{y\sqrt{(\tau_0/\rho)}}{\nu}\right)$ or $g\left(\frac{y}{\delta_l}\right)$ the "universal velocity distribution" due to the wall friction. The first empirical theory of the turbulent flow, especially of the turbu-

lent boundary layer, advanced by Prandtl and the present author more than 10 years ago, substituted for this function a certain power of the argument $\frac{u}{\sqrt{(\tau_0/\rho)}} = C\left(\frac{y\sqrt{(\tau_0/\rho)}}{\nu}\right)^n$, the exponent n being determined experimentally. The present author has shown that, assuming similarity or constant correlation of the turbulent flow pattern, the function g takes the form

$$g\left(\frac{y\sqrt{(\tau_0/\rho)}}{\nu}\right) = A + B\log\frac{y\sqrt{(\tau_0/\rho)}}{\nu}$$

where A and B are numerical constants. The logarithmic term can be obtained from the equation $\tau = \rho l^2\left|\frac{dU}{dy}\right|\frac{dU}{dy}$, putting $l = \kappa y$, i.e., letting the mixing length be proportional to the distance from the wall, and substituting for the varible τ in the first approximation its limiting value τ_0. The constant κ appears in the theory as a universal constant; thus we write

$$\frac{u}{\sqrt{(\tau_0/\rho)}} = A + \frac{1}{\kappa}\log\frac{y\sqrt{(\tau_0/\rho)}}{\nu} \quad \ldots\ldots\ldots [8]$$

Using Equations [6] and [8] and the definition of λ given by [5a] we obtain the following relation between the friction coefficient λ and the Reynolds number R

$$\sqrt{\frac{2}{\lambda}} = \text{const} + \frac{1}{\kappa}\log(R\sqrt{\lambda}) \quad \ldots\ldots\ldots [9]$$

This relation was given for the first time in the aforementioned paper and adopted later by Dr. Prandtl and Nikuradse. It is in fair agreement with the experiments in a wide range of Reynolds' number. A disadvantage of the formula is that it cannot be resolved for λ; thus a chart might be preferable.

The values of the numerical constants which best fit the experiments are

$$\left.\begin{aligned}\frac{u}{\sqrt{(\tau_0/\rho)}} &= 5.25 + 5.8\log_{10}\left(\frac{y\sqrt{(\tau_0/\rho)}}{\nu}\right)\\ \sqrt{\frac{2}{\lambda}} &= -1.16 + 5.8\log_{10}(R\sqrt{\lambda})\end{aligned}\right\} \quad \ldots [10]$$

or in a more convenient form

$$\frac{0.244}{\sqrt{\lambda}} = \log_{10}\left(\frac{R\sqrt{\lambda}}{1.58}\right)$$

It might be noticed that the theory sketched here is not a pure theory in the proper sense, because two constants remain to be determined by experiment. However, the form of the function $\lambda = f(R)$ is found by pure theoretical reasoning, and it is hoped that the constants do not belong to the class of the "variable constants."

FLOW IN ROUGH CONDUITS

The influence of roughness is too complicated to be discussed in detail here. It seems that its influence is negligible, as long as the height of the protuberances is small in comparison with the thickness of the laminar sublayer. There is no adequate theory for the case where both quantities are of the same order. If the height differences at the surface are large compared with the thickness of the laminar sublayer, we obtain by reasoning similar to that already applied the following results, confirmed by experience, at least in so far as artificially roughened surfaces are concerned:

(a) That the friction coefficient is a function only of the relative roughness, and independent of the Reynolds number (or of viscosity).

(b) That the friction coefficient is connected with the relative roughness ϵ/r (ϵ is the average linear dimension of the protruding part, r the half distance of the walls)

$$\sqrt{\frac{2}{\lambda}} = \text{const} + \frac{1}{\kappa}\log\frac{r}{\epsilon} \quad \ldots\ldots\ldots [11]$$

The experimentally obtained value of the constant κ is the same as in Equation [9]. This might be considered as proof that the reasoning leading to the different equations is correct.

This last formula enables us in some cases to extrapolate from model to full scale, if we know that the absolute roughness of the surface is the same, as, for instance, in the case where the surface of the model and the full-scale object is finished in the same way. However, we should obtain more benefit from this result if an adequate "scale for roughness" could be established. A single roughness parameter probably will not be sufficient to determine the roughness. This and other questions concerning the subject are yet largely open for discussion. Also the results for artificial roughness and natural roughness are not quite consistent; and the theoretical form of the general relation giving λ as function of both the relative roughness and the Reynolds number is not yet known.

FLOW OF A FREE STREAM ALONG A SURFACE (SKIN FRICTION)

The conclusions of the turbulence theory applied to this problem have been discussed by the present author in a paper published recently in the *Journal of the Aeronautical Sciences*.[3] The relation obtained between the friction coefficient C_f (de-

[3] "Turbulence and Skin Friction," by Th. von Kármán, *Journal of the Aeronautical Sciences*, vol. 1, no. 1, January, 1934.

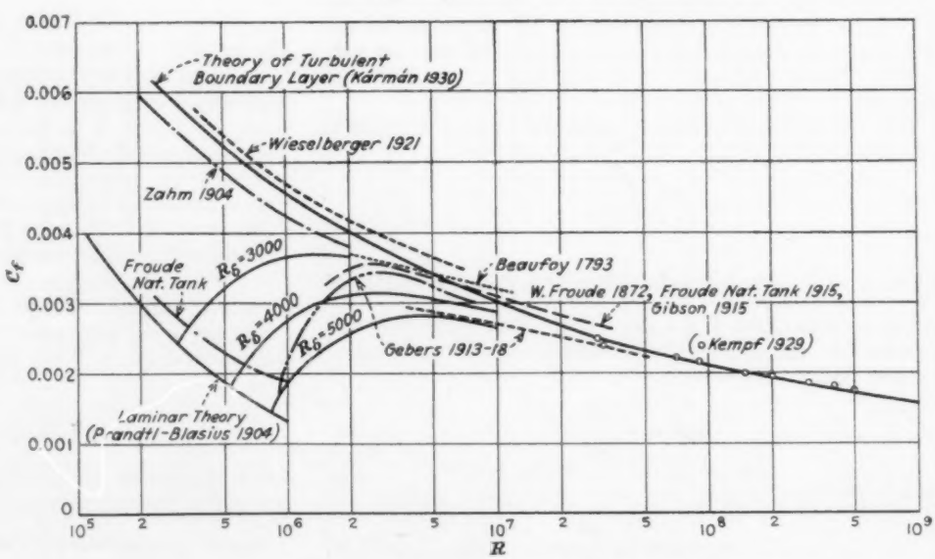


FIG. 3 SKIN FRICTION OF SMOOTH PLATES COMPARED WITH THE THEORY
(Curve marked "Theory of Turbulent Boundary Layer" corresponding to Equation [13].)

fined as $C_f = \frac{F}{A\rho U^2/2}$, where F is the total friction, and A the wetted area) and the Reynolds number of a plate $R = Ul/\nu$ (l is the length of the plate from the leading to the trailing edge and U the velocity of the free stream) is given by the formula

$$\sqrt{\frac{2}{C_f}} = \text{const} + \frac{1}{\kappa} \log (RC_f) \ldots\ldots\ldots [12]$$

with adequate coefficients (determined by E. Schoenherr) as follows:

$$\frac{0.242}{\sqrt{C_f}} = \log_{10}(RC_f) \ldots\ldots\ldots\ldots [13]$$

The agreement of this formula with experiment is shown in Fig. 3.

It may be of some interest to know how this formula or the corresponding chart is used at the Guggenheim Aeronautics Laboratory of the California Institute of Technology in Pasadena for the high-speed prediction of modern airplanes. If power available and wing area are given, the top speed of airplanes depends chiefly on the coefficient of the parasite drag. We assume that one part of this drag is contributed by pure skin friction, another part is due to the form resistance of protruding parts and to wake formation at the fuselage. After measuring the coefficient of the parasite drag at the maximum Reynolds number available in the wind-tunnel tests, we draw two curves:

(*a*) One corresponding to the assumption that the whole drag obeys the skin-friction law, i.e., the drag coefficient C_{D_p} decreases with increasing Reynolds' number as C_f decreases with R according to Equation [13].

(*b*) Another curve corresponding to the assumption that only the drag of the wing follows the skin-friction law, all additional drag is independent of viscosity (or of Reynolds' number).

Obviously, assumption (*a*) is too optimistic; assumption (*b*) is too conservative for the extrapolation to full scale. In order to obtain the probable correct answer, we extend these computed curves to lower Reynolds' number and measure the same drag coefficient at different values of Reynolds' number, varying the velocity in the wind tunnel between the available limits. The location of the experimental points between the two curves (*a*) and (*b*) allows us to estimate the fraction of the drag following the skin-friction law and that independent of viscosity. In this way, eventually, after making some allowance for protuberances such as rivet heads, not represented in the model, we obtain a very close estimate for the speed of the full-scale ship.

EFFECT OF TURBULENT FRICTION ON DISSIPATION OF VELOCITY DIFFERENCES

In several practical cases there is a definite initial velocity difference between the fluid masses, and it is a question how the process of the dissipation of this velocity difference is affected by the turbulent friction. A few examples worth mentioning are: The dispersion of a fluid jet in an indefinitely extended fluid mass, the dissipation of the wake behind a body moving through a fluid, and the flow in a pipe with sudden change of cross-section. Some of these problems have been attacked theoretically by Prandtl, Tollmien, and others; Prandtl uses the term "free turbulence" for this sort of problem. In the theoretical calculations, an average constant value of the mixing length is assumed over every cross-section, i.e., over the region in which the velocity transition takes place, the mixing length being variable in the direction of the main flow. These calculations are, in general, in fair accordance with the experimental facts, or more exactly, they can be made to fit the observations by introducing a few empirical numerical factors. Perhaps the most significant result of these investigations is the relatively high value obtained for the magnitude of the turbulent friction between fluid and fluid, compared with the friction along a solid surface. Consider, for instance, the simple case of two fluid masses, one having the velocity U in the x-direction, and the other being initially in rest. (Fig. 5.) The apparent shearing stress, acting between the two fluid masses

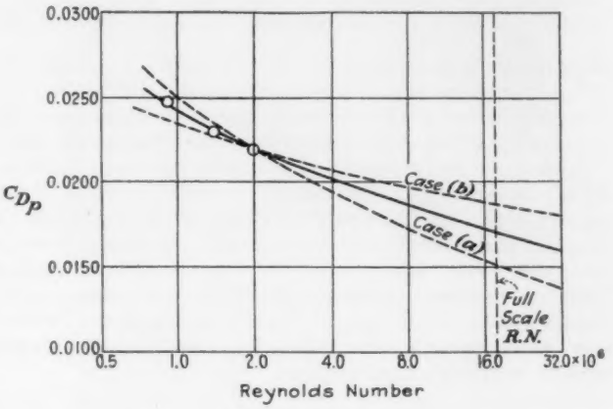


FIG. 4 EXTRAPOLATION OF PARASITE-DRAG COEFFICIENT FROM WIND-TUNNEL RESULTS TO FULL-SCALE REYNOLDS' NUMBER

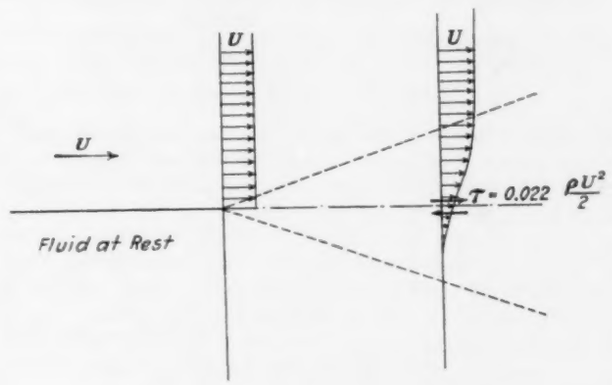


FIG. 5 MIXING OF TWO FLUID MASSES

in the center of the mixing region, is found to be constant in the x-direction and has the magnitude $\sim 0.022 \frac{\rho U^2}{2}$. Let us compare this value with the magnitude of the skin friction along a solid wall. To be sure, in the latter case the friction is theoretically infinite at the leading edge, but its value drops so rapidly that, as an example, assuming water as fluid and U equal to 1 meter per sec, at a distance of only 1 cm from the leading edge, the local friction amounts to only $0.006 \frac{\rho U^2}{2}$ and in most practical cases the value of the mean skin-friction coefficient is between 0.002 and 0.004. Thus the friction between fluid and fluid is rather large due to the intensive turbulent fluctuations in the case of "free turbulence." I believe that these recent theoretical researches deserve the interest of the hydraulic engineers.

PROBLEM OF HEAT TRANSFER

The problem of heat transfer between a solid and a fluid in turbulent motion has been the subject of a number of papers

and discussions published in the last few years in technical magazines in this country and abroad. Practically all authors agree that two main parameters enter into the problem: The Reynolds number R and a parameter composed of the physical constants of the fluid $\sigma = \nu C_p/k$ where ν is the kinematic viscosity, C_p the specific heat of the unit volume, and k the coefficient of molecular heat conduction. Denoting the heat transferred per unit area in unit time by q, the mean velocity by V, and the temperature difference between the wall and the center of the pipe by Θ, the dimensionless quantity $\frac{q}{C_pV\Theta}$ will be a function of the two parameters R and σ only. There are two different suggestions for the computation of q: Nusselt in Germany and Boelter and Dittus in this country proposed empirical equations based on dimensional analysis and putting the heat-transfer coefficient proportional to certain powers of R and σ, where the exponents are determined empirically. Some of the authors prefer the so-called Prandtl-Taylor formula which is based on the assumption that the heat is transferred by mere molecular conduction through the laminar sublayer (called "film" in literature on chemistry) and by pure turbulent convection outside of this layer. Prandtl calculated the "thickness" of the laminar layer from a $^1/_7$-power formula for the velocity distribution and obtained

$$\frac{q}{C_pV\Theta} = \frac{0.0396R^{-1/4}}{1 + 1.74R^{-1/8}(\sigma - 1)} \quad \ldots\ldots [14]$$

In the range of R considered, the friction coefficient of the pipe is approximately equal to $\lambda = \frac{0.0792}{R^{1/4}}$ so that for $\sigma = 1$, $\frac{q}{C_pV\Theta} = \frac{\lambda}{2}$. This result is in good agreement with the measurement. However, the Prandtl formula checks the experiments only for values of σ which are not very different from unity. In the case of gases k has the same order of magnitude as νC_p, but in the case of liquids (water, oil) a very large range for $\sigma (3 < \sigma < 80)$ has to be considered. It seems that in the case of large values of σ, i.e., if the molecular heat conduction is very small compared with the molecular momentum transfer, the simple division between film and turbulent region is not allowable, but instead a transition region has to be taken into account in which laminar friction and turbulent friction are of the same order.

Using our new knowledge about the velocity distribution, I have obtained the formula

$$\frac{q}{C_pV\Theta} = \frac{\frac{1}{2}\lambda}{1 + \sqrt{\frac{\lambda}{2}} f(\sigma - 1)} \quad \ldots\ldots [15]$$

where $f(\sigma - 1) = 5[\sigma - 1 + \log_e\{1 + 0.83(\sigma - 1)\}]$. It seems that this formula checks the experiments much better than the Prandtl equation.

PROBLEM OF SEDIMENT

The problem of the distribution of transported sediment through the cross-section of a river or a channel is obviously connected with the problem of turbulent motion. Prof. M. P. O'Bryan, in a recent paper, gave the basic equation for the statistical equilibrium of the sediment. This equation is somewhat further developed in the following lines. Let us consider the fraction of sediment corresponding to a certain size or having a certain rate of fall w. If the number of particles of this definite size in unit space is n, the number falling through unit area of the horizontal x-y plane will be nw. On the other hand the transfer in the vertical direction from the region of higher concentration to a region of lower concentration will be $-l|w'|\frac{dn}{dz}$. Therefore the condition of statistical equilibrium is

$$nw = -l|w'|\frac{dn}{dz} \quad \ldots\ldots [16]$$

or

$$\frac{dn}{n} = -\frac{w}{|w'|}\frac{1}{l}dz \quad \ldots\ldots [16a]$$

Now denoting the local shearing stress by τ, and the local mean velocity of flow by $\bar{u}$ we have the relation

$$\tau = \rho l|w'|\frac{d\bar{u}}{dz}$$

or

$$l|w'| = \frac{\tau}{\rho\frac{d\bar{u}}{dz}}$$

Introducing this expression in Equation [16a], we obtain

$$\frac{dn}{n} = -\frac{\rho\frac{d\bar{u}}{dz}w}{\tau}dz$$

or

$$\log\frac{n_0}{n} = \rho w\int_0^z \frac{d\bar{u}}{dz}\frac{dz}{\tau} \quad \ldots\ldots [17]$$

where n_0 is the number of particles transported on the bottom. For a broad channel or river $\tau = \tau_0\left(1 - \frac{z}{d}\right)$, where τ_0 is the friction at the bottom and d is the depth of the flow. Denoting $z/d = \zeta$ and putting $\bar{u} = Vf(\zeta)$, where V is the mean velocity $f(\zeta)$ the velocity-distribution function, we obtain

$$\log\frac{n_0}{n} = \frac{\rho Vw}{\tau_0}\int_0^\zeta \frac{f'(\zeta)}{1 - \zeta}d\zeta = \frac{\rho Vw}{\tau_0}F(\zeta)$$

Finally we put $\tau_0 = \rho g d\alpha$ (α = hydraulic slope) and $V = c\sqrt{gd\alpha}$. Hence

$$\log\frac{n_0}{n} = \frac{cw}{\sqrt{gd\alpha}}F(\zeta)$$

$$n = n_0 e^{-\frac{cw}{\sqrt{gd\alpha}}F(\zeta)} \quad \ldots\ldots [18]$$

Computing $F(\zeta)$ from measured velocity distributions n/n_0, i.e., the distribution of the different fractions of sediment can be calculated and compared with the experiments. It must be noticed that the equation does not tell anything about the total amount of the transportation, since n_0 is left undetermined; the magnitude of n_0 depends largely on the size of the sediment and on the magnitude of the shearing stress acting at the ground.

ON APRIL 27, at Montecelio, Signor Mussolini performed two inauguration ceremonies. The first was that of the new Italian experimental air station, said to be one of the most up to date in the world. The second was that of the town of Guidonia, which has been built on the site where General Guigoni was killed during parachute experiments some seven years ago.—*The Engineer*, May 3, 1935, p. 453.

FIG. 1 PHOTOMICROGRAPH OF PLASTIC-BRONZE SPECIMEN NO. 2468 COMPRESSED, ETCHED WITH FERRIC CHLORIDE (×100)

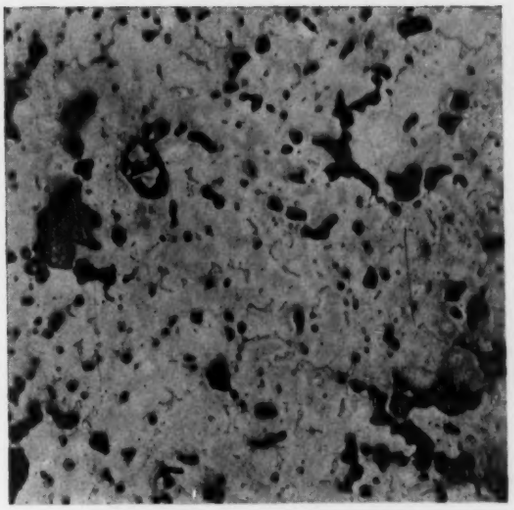


FIG. 2 PHOTOMICROGRAPH OF PLASTIC-BRONZE SPECIMEN NO. 2468 ETCHED WITH FERRIC CHLORIDE (×100)

(Oil in Fig. 2 is indicated by presence of dark lines around the black spots, which are lead.)

ARE METALS PERMEABLE BY OIL?

Experiment Shows That Leaded Bronze and Babbitt Metal Absorb Oil

By AUGUSTUS H. GILL

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

THIS question has been asked from time to time, and, in so far as the author is informed, no wholly satisfactory answer has been returned. The probability is that bronzes and babbitt metals do absorb oils.[1] The nearest approach to an answer is given by Woodbury[2] who says, in describing the Ordway-Woodbury machine:

After cleaning with gasoline and wiping carefully with wash leather, the disks—one of hard bronze, the other of hardened steel—are oiled and run for about five hours, being kept cool by a stream of water circulating through the upper disk. From time to time they are taken apart, cleaned, and oiled again. After using any oil, even if the disks are afterward cleaned, the results with the oil subsequently used give the characteristics of the previous oil, and it is only after 35 to 45 miles of attrition that these results become consistent with each other; each succeeding result, meantime, approaching the final series. This seems to indicate that friction exists at the surface of the two disks, between the film of oil acting as a washer and the globules of oil partially embedded within the pores of the metal. If the dense bronze and steel retain the oil despite attempts to remove it, how much longer must it require to replace the oil in machinery with a new variety whose merits are to be tested? These experiments confirm the wisdom of the increasing use of cast iron for journals, as its porosity enables it to contain and distribute the lubricant.

A similar answer is given by Conradson[3] who was testing pieces from a locomotive driving-journal brass that had been long in service and given exceptional performance; its composition was copper and tin with 12 per cent of lead. The pieces were being tested under compression, and to his "surprise oil began to come out in quantities as the pressure increased." He further states:

Some 30 years ago I was conducting comparative frictional tests on the large Galena oil-testing machine—test journal 9 in. long, 5 in. in diameter; speed 600 rpm; load approximately 600 lb per sq in.; oil bath; bearing, genuine babbitt metal (tin base) about 2 in. thick with two square cavities on top.

After running a test for a few days, it was noticed that some of the oil had disappeared. As the running temperatures were far below the evaporation point of the oil, it was rather puzzling.

On removing the bearing the two cavities on top were practically *full* of oil. After cementing or gluing the junctions between the bearing and the block on top, to prevent the possibility of any oil entering this way, the test was resumed. After a few days' running under same conditions, the test bearing was removed and the two cavities were again nearly full of oil.

Conradson[4] quotes further data supplied to him by James Duguid, now connected with the Standard Oil Company of New York, and refers to his experience as follows:

The bearing which he used was hard bronze, machined all over, was $3\frac{1}{2}$ by 6 in., and was used for test purposes on a Riehle-type testing machine. The cooling water enters the bearing through a funnel at-

[1] C. G. Williams, *Engineering*, vol. 134, Nov. 11, 1932, p. 573.

[2] "Measurements of the Friction of Lubricating Oils," by C. J. H. Woodbury, Trans A.S.M.E., vol. 1, 1880, chapter 7.

[3] Letter of June 5, 1932.

[4] Discussion of paper entitled "Chemistry of Lubrication," by W. F. Parish and Leon Cammen, presented at the A.S.M.E. Annual Meeting, New York, N. Y., Dec. 5 to 9, 1932.

tached to the bearing at inlet cooling hole, and after passing through the bearing flows out through a drain pipe attached to bearing at outlet hole. When making tests with this bearing it became quite apparent that in order to get uniform cooling efficiency, it was necessary to clean out cooling holes frequently. When cleaning out these cooling holes, he noticed that the cleaning swab used was heavily saturated with oil and suspected that there was a leakage from the bearing surface to these cooling holes due to some defect in the metal, such as porosity, etc. To make a test for leakage of cooling water to the bearing surface and therefore affecting test results, he subjected the cooling cavities to hydrostatic pressure of 60 lb per sq in., and under this pressure for one hour, he could not find the slightest evidence of moisture on any face of the bearing. Mr. Duguid concluded that the oil that entered the cooling holes in this bearing came from the rubbing surface where the oil film is under heavy pressure. The tests when the oil in the cooling holes became apparent were made at speeds of 1000 rpm and loads of 800 lb per sq in. on the projected area of the journal.

Woodbury washed the old oil out of the bronze with the new, and Conradson and Duguid actually squeezed the oil out of babbitt and bronze under pressure, like juice from an apple.

The author has obtained the oil by another process—actual extraction of the bronze chips with solvents:

Bronze. The bronze metal used was a piece of that tested by Dr. Conradson (No. 2468) and was in the form of a cylinder 2 in. long by about 0.84 in. in diameter. This was turned down by successive chips 0.02 in., or later 0.03 in. thick, until it was about 0.26 in. in diameter. It had a greasy feel but left no trace of oil upon wiping, and was turned down with a dry tool of self-hardening steel. These chips amounting to 6 or 8 g each were extracted with ether in a Soxhlet extractor[5] for eight hours. The results are as given in Table 1.

It will be noticed that the different cuts are remarkably uniform regarding their oil content. No doubt the remaining quarter-inch cylinder would show the same result. The bronze contained 0.37 per cent oil by weight, and about ten times as much, 3.6 per cent, by volume. The oil was a dark-brown mineral oil; the ether left no residue on evaporation. To make sure that all the oil was removed, a second extraction of the chips was made with benzol for eight hours, and in some cases no additional oil, or only the merest trace, was obtained. Benzol was used to dissolve any tarry matter that the oil may have contained or that may have been formed in use.

[5] In this device the chips are drenched and soaked in ether, going into a flask below whence the ether boiled off, condenses and drops into the extractor again, and so on at the rate of about five refillings per hour.

TABLE 1

Cut no.	Thickness, in.	Per cent oil in bronze	Cut no.	Thickness, in.	Per cent oil in bronze
1	0.02	0.42	7	0.03	0.39
2	0.01	0.37	8	0.03	0.38
3	0.02	0.39	9	0.03	0.32
4	0.02	0.38	10	0.03	0.37
5	0.03	0.34	11	0.03	0.38
6	0.03	0.39	..	....	....
					Average 0.377

The result confirms the aforementioned observation of Conradson and would seem to leave no doubt but that bronze and probably babbitt metals absorb oil.

The photomicrographs show the appearance of the bronze, the black areas being lead. It will be seen in Fig. 2 that some of the black areas are surrounded by a heavy black line which the metallographer believes is oil.

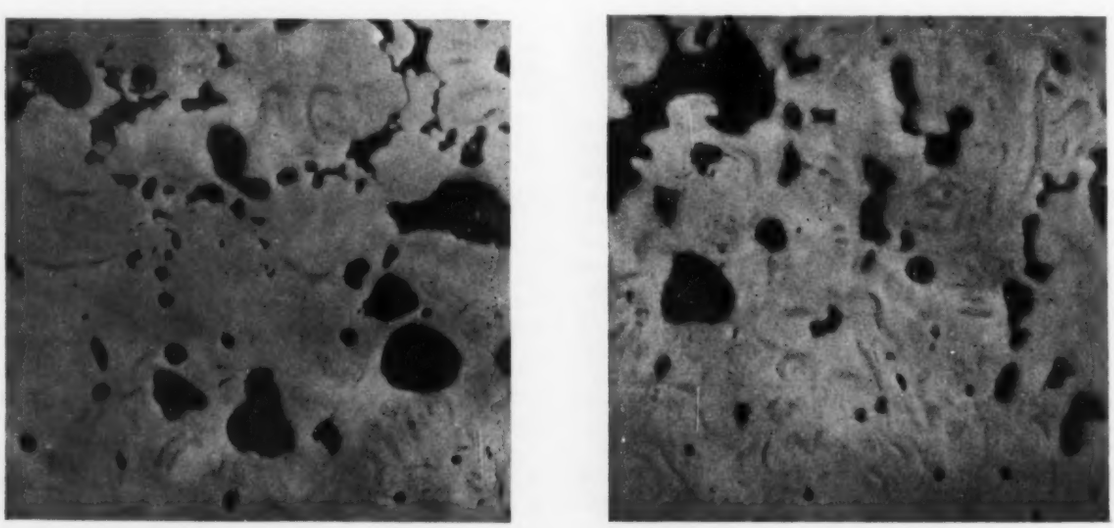
Steel. There was sent at the same time as the bronze, a test piece of steel from a locomotive driving journal which had been long in use and also given unusually good service. It had been machined down when originally made and any slag, fissures, or scales of metal removed. Similar chips were taken from this on a shaper, extracted, and no oil whatsoever obtained, showing the impermeability of the steel.

Chips from a cast-iron journal half an inch in diameter also showed no oil following a 24-hr extraction.

CONCLUSIONS

From these experiments it would seem that leaded bronze will absorb about 0.3 per cent of oil, and that it penetrates at least 0.375 in. Mild steel did not absorb oil. According to Conradson, who squeezed the oil out of babbitt metal, it also absorbs oil.

The author is indebted to his colleagues Professor Williams, for the photographs, and Mr. Lawson for the machine work, to whom he wishes to express appreciation.



PHOTOMICROGRAPHS OF PLASTIC BRONZE SPECIMENS ETCHED WITH $NH_4OH + H_2O_2$ (×100)

STEEL-PLANT LUBRICATION

By B. S. BURRELL

INLAND STEEL COMPANY, INDIANA HARBOR, IND.

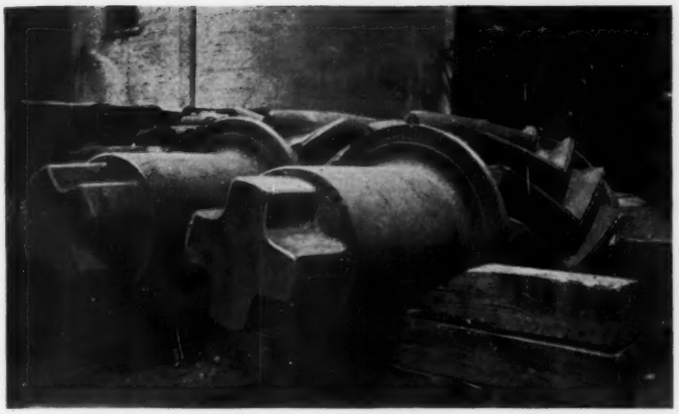


FIG. 1 WEAR ON 36-IN. BLOOMING-MILL PINIONS MADE OF 45- TO 50-POINT CARBON, WITH 3 PER CENT NICKEL

(One of the earlier types of cast-tooth pinions, fully enclosed, installed about twenty years ago. The average life of gears in this housing, lubricated with the usual types of residuum gear shields, was approximately 400,000 tons.)

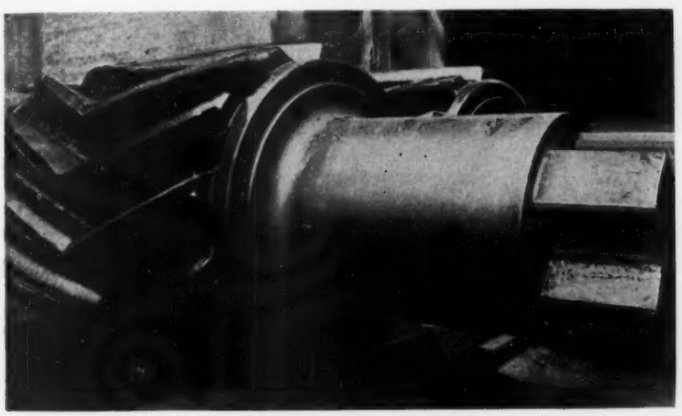


FIG. 2 36-IN. BLOOMING-MILL PINION OF SAME SPECIFICATIONS AS THOSE OF FIG. 1 AFTER ROLLING 400,000 TONS, LUBRICATED WITH A FIBROUS-STRUCTURE, EXTREME-PRESSURE, ASPHALTIC-BASE OIL

(Little wear will be noted as compared with that shown in Fig. 1. These gears are still in service and to date they have rolled 1,500,000 tons. Figs. 1 and 2 illustrate the need for special types of lubricants in the steel industry.)

LUBRICATION in any industrial plant is of first importance. In steel mills many difficult problems confront the operating forces, requiring a study of each piece of equipment and the best lubricant and method of application decided upon to secure long life of machinery and a low repair and maintenance cost.

Much credit is due machinery designers and builders for present types of mills; but in many cases there is much to be done about the design for their proper lubrication. Reduction gears, pinion stands, and other geared units are still being built for two kinds of lubricants, one for the bearings and one for the gears. The use of two lubricants is a constant burden to the mechanical department in preventing contamination of one lubricant with another.

There is need for greater use of special types of lubricants in steel mills, both for new and old equipment. Such lubricants have assisted in solving many lubrication problems, increasing the life of equipment, and decreasing maintenance and repair costs. While some cost more per pound or gallon they have been less costly per ton of product shipped.

Like most mills the Inland Steel Company has used various shields of the residuum type for open gears. These have been replaced to a large extent by shields manufactured from blends, processed to make them softer in relation to the melting point than the ordinary residuum shields, giving them spreading qualities which result in a better covering of the bearing surfaces of the teeth, and prolonging the service from a given application.

For enclosed gears, where lubricants are required to absorb shocks and resist high pressures, we are using a new type of lubricant designated in technical literature as a "fibrous-structure extreme-pressure lubricant." Lubricants of this type do not have to be heated to apply. They retain a fluid-plastic body under wide extremes of temperature conditions. They do not "set" in cold weather and, therefore, absorb less energy. Regardless of the weather or operating condition, they carry up on the gears freely and build up a lacquer-like film on the gear teeth.

While many steel mills are being equipped with new machinery of the finest type, obsolete and antiquated mills are still being operated. In most cases these mills were designed to be lubricated with tarry shields. The excessive power consumption resulting from this method of lubrication has unquestionably been enormous. The replacement and maintenance costs have been great. We have been able to improve greatly the lubrication condition of this type of equipment in our plant by minor mechanical changes and by the adoption of a more suitable lubricant. A number of our important installations are operating much more satisfactorily than they were previously, because we have been using more suitable lubricants. For example, the life of a set of 36-in. blooming-mill pinions has been practically trebled and the cost of lubrication per ton of product produced has been lowered, although the cost of the lubricant per pound is treble that of the lubricant previously used. Similar records have been made for other gear sets.

We have large geared units which contain the original special lubricant with which they were started up—some as much as eight to ten years ago—to which only nominal amounts have been added from time to time to maintain the proper level in the housings. These housings are very nearly dustproof.

These special types of lubricants are lubricating the major portion of our geared units, but for other mill use the ordinary types of refinery products give satisfactory performance.

Oil lubrication with circulating and filtering systems is being

Condensed from a paper contributed by the Iron and Steel Division and presented at the Annual Meeting, New York, N. Y., December 3–7, 1934, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

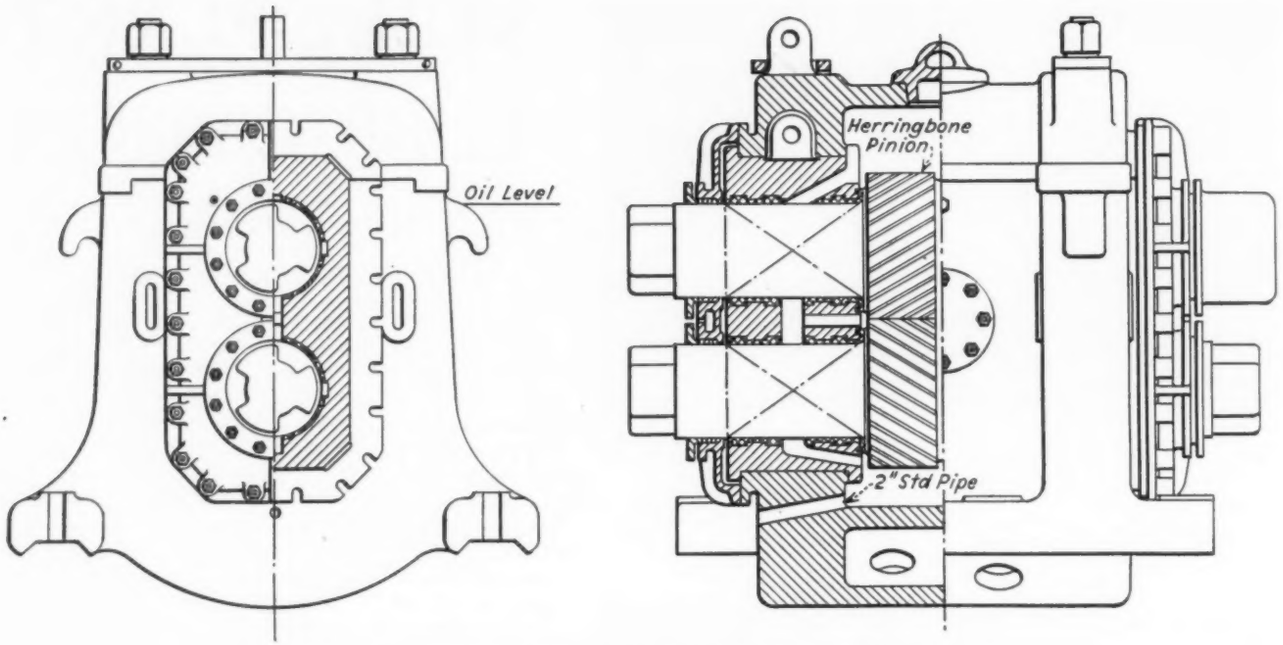


FIG. 3 FULLY ENCLOSED SEALED PINION STAND FOR A 24-IN. SHEET BAR MILL
(This stand was lubricated with these special lubricants, same material for necks and teeth, and was operated for five years during the busiest period without removing the housing cap.)

used with good results on speed-reduction sets and mill-pinion stands of merchant and strip mills—the same material lubricating both teeth and bearings. These systems work best with gears of the higher carbon and hardened types.

The viscosity of the oil in a circulating system subject to mechanical agitation, air, moisture, and mill dust is sure to be affected, the degree depending upon the quality of the oil, the amount of "make-up" oil, and the compounds, if any, that have been used in it. It is also affected by the efficiency of the filtering system. The viscosity may become lowered in some cases. In others, it may be raised, even to the extent of forming a sludge.

The wisdom of frequent checking of the oil in all systems is strongly urged. The oil should be tested for foreign substances, and laboratory tests made every three to six months and oftener if the preliminary checks of the condition of the oils indicate that it is necessary.

Like most all mills, at one time we were large users of so-called "black oil." While low in first cost, it was expensive to use. We now use cylinder stock oil in most all cases. The cost per gallon is more, but the results are better and the final cost is less.

Lubrication of roll necks of the open-bearing type is a distinctly separate branch of mill lubrication. For cold necks, the more common types of tallow compounds and some suet continue to constitute the bulk of the lubricant used as in the past. Improved types of mills and mechanical means of applying the lubricant have led to the development of wholly different kinds of roll-neck lubricants, from the standard types of heavy oils and extreme-pressure lubricants, oils and greases, to greases of various types.

Hot-neck lubricants, to a large extent, are the same as have been used for many years. A tarry, heat-resisting substance is applied in the form of slabs laid up against the neck to melt as it will or is melted in a pan and swabbed on by the operators. Some hot-neck lubricants have been developed for mechanical application by lubricating systems. The lubricant manufacturers are working to better this condition, but there is much yet to be done.

Another special lubricant found profitable is of the cup-grease type, but with a certain degree of fluidity, depending upon the number used. This has been particularly advantageous for lubricating the wool-waste-packed bearings of overhead cranes. Where used, it has eliminated the drip of lubricant from the runways.

Good progress has been made by the manufacturers of anti-friction bearings of the roller and ball types, and the use of these has lessened the difficulties of lubrication and excessive bearing wear. The lubrication of the ball and roller bearings used on miscellaneous machinery is usually accomplished with the regular types of lubricants, while the roller bearings operating on roll-train roll necks, which are subject to excessive pressures, require an entirely new type of roll-neck lubricant. The extreme-pressure products are for this work; while some oil is used, more grease is employed. Because most bearing seals now in use leak, replenishments are constantly necessary. Hence the quality of the lubricant is periodically built up. With a leak-proof seal, certain changes of the lubricant may be necessary to do the work constantly with little or no replenishment for comparatively long periods of time.

A complete automatic centralized greasing system in use on the roll-train bearings of our 76-in. hot-strip mill operates at a pressure of 2000 lb per sq in. The amount of grease applied to each bearing is regulated by a valve near it, and the frequency of greasing all the bearings at the same time is regulated automatically from the central station. This is done every 15 min in our case. Temperatures of all back-up roll bearings are recorded by a pyrometer. An attendant is constantly observing these readings for possible difficulty with any particular bearing. This entire lubricating and temperature-recording system has been in use for nearly three years and has been found to be very reliable. An extreme-pressure leaded compound is used for the roll-train roller bearings of this mill. Centralized systems are in use on all of our cold-strip mills.

Sleeve-type and half-shell bearings that have served many years on heavy operating machinery have become obsolete since the ball and roller bearings have shown such good results.

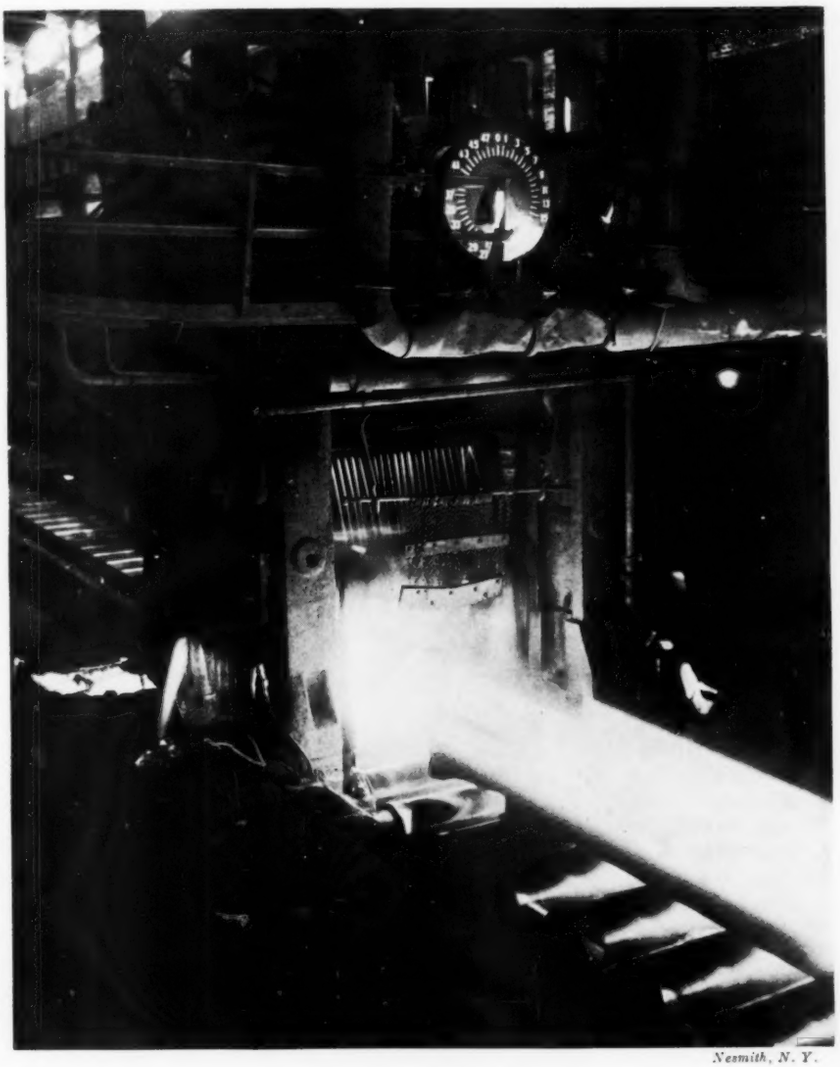
It is not my purpose to belittle anti-friction bearings. Much credit for design and precision manufacturing must be directed to the producers of this type of bearing. However, if the same protection against dirt and other contamination were given the sleeve and split-shell bearings as has been given the anti-friction bearings, they would give a good account of themselves, and their lubrication, which is now a constant burden, would become simple. What is needed is good alignment, a clean efficient oil film maintained by the use of seals and dust shields, and the cutting down of the present large clearances to a reasonable working amount. Manufacturers of these old types of bearings are constantly striving to produce a metal that will last longer under the present dirty working conditions, and they have done a creditable job of it. However, it is my opinion that a change to general cleanliness will give us what we want—a good long life for such bearings.

The installation of centralized lubricating systems is recommended wherever practicable. Investments in this type of equipment have shown excellent returns. Good results are being obtained from these systems on roll trains equipped with the old-style babbitted and brass bearings. The life has been increased many times, and a power saving of 15 to 35 per cent has been shown. Less wear takes place daily and closer alignment of rolls is maintained, resulting in a better rolled product.

The merits of centralized lubrication systems on roll trains equipped with roller bearings are acknowledged as necessary for the successful operation of this type of bearing.

Dust and dirt are the known enemies of the steel plant and are the cause of large repair and maintenance costs. Regardless of the quality of lubricant, if it is being continually contaminated with gritty dirt, it cannot perform its function correctly. A compound of oil or grease, dust, and dirt, makes a lapping medium that is continually wearing down bearings and gearing. Therefore, a campaign to eliminate as much as possible this ever-present enemy should be carried on. A sincere effort along this line will bring about material reductions in repair and maintenance costs.

From a lubrication standpoint, my recommendation is to use high-grade products with the proper degree of cleanliness and economy in order to obtain the lowest power, repair, and maintenance costs, the greatest yield, and the most uniform products.



Nesmith, N. Y.

BLOOMING MILL IN OPERATION

COLLEGE OF ENGINEERING AND COMMERCE AND SCHOOL OF APPLIED ARTS, UNIVERSITY OF CINCINNATI

Backgrounds of the COOPERATIVE SYSTEM

By HERMAN SCHNEIDER

UNIVERSITY OF CINCINNATI

THE THEORY of the cooperative system is very simple. Engineers, like doctors and lawyers, are trained for practice. Judgment based upon experience must supplement theory. The four-year plan of training engineers evolved in liberal-arts colleges and was merely a convenient extension, in form, of the liberal-arts system. Having graduated, the engineer, like the doctor, could not practice. He had a fair amount of principles but lacked sadly in knowledge of the other elements of his profession—men, materials, methods, and mechanisms. Hence an apprentice system came into being, covering a period of two or three years. Principles and practice were driven tandem instead of abreast. Prospective engineering practitioners were withdrawn from active life during their impressionable years, in order to prepare for active life. They had no tests of their abilities in their chosen fields until the major part of their preparation was completed. In civil engineering, for example, more than half the men trained for that profession quit it within a few years. (In the cooperative system less than ten per cent do.)

Withdrawing from life into monasteries met a need during the turbulent centuries in which life at large offered little to the intellect; but today life at large cries out for intelligence trained in theory and in practice, prepared to adjust theory with the proper factors of safety to practical problems without number.

The ideal state presupposes ideal men. But mankind is cantankerous and life develops into a series of compromises. The best state possible comes from the wisest adjustment of perfect theory to imperfect man. This adjustment in practical life needs experts who know perfect theory and imperfect man plus the mechanisms he uses in production and government. The theory can best be learned in school; and understanding of man and his mechanisms can be learned only where they operate. A man trained through to a Ph.D. in the social sciences without the realism of practical contacts would have a bitter experience, for example, in organizing and operating a relief station for the unemployed. So would the unemployed. The management of men, as of materials, needs a knowledge that cannot be told. Training in precept only leaves us all children in the work-a-day world; we learn to walk among men by stumbling and getting bumped rather than by lectures on gravity. But just to learn to walk by being bumped does not teach a man the skilled handling of the force of gravity.

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Idealism in action presupposes a goal, and a straight line is the shortest distance between two points. But goals are never achieved on straight lines. The surges within and without us usually make the path like that of a buffeted ship. How to meet the winds and the waves on the bridge of a liner cannot be learned from books on meteorology. Conversely, a practical navigator can more nearly approximate the straight line to his destination by a knowledge of what lies back of a weather report. The theorist who imagines he has a straight line clear to his goal becomes as bewildered as a fly trying to go through a window pane. If the fly knew about window panes it would take a more devious but surer and quicker path to where it wants to go, rather than struggle without progress along the apparent straight line.

All of this means that there is a philosophy of approaching the ideal which takes into account the forces lying between us and our purposes and which must be met and turned to our uses. Knowledge of some of these forces lies in books; of others not. But they all weave into the successful doing of our tasks. And no matter what field of endeavor we train men for, the weaving should begin with the simpler elements of both and should be intimate and progressive.

So the major idea underlying the cooperative system is that of balanced training to insure the highest attainment through the skilled use of all of the factors involved—theory, men, materials, methods, and mechanisms.

There are many beneficial by-products to the system.

It conserves time. By reason of the alternation of theoretical work and practical work, the student can carry a heavier load of studies per period than would be possible if he attended school full time. At graduation from the five-year cooperative course our student has covered more theoretical work than a student does in the four-year full-time courses. This has been established by an investigation, covering the leading engineering colleges of the country, made by Prof. William T. Magruder, of Ohio State University, and published in the bulletin of The Society for the Promotion of Engineering Education, October, 1933. In addition, the cooperative student has been given 5500 hours of sequential training in his field of practice, a training organized by the college as carefully as its curriculum, and coordinated with the theory taught. Hence the cooperative student is as far advanced at the end of five years as the regular student is at the end of eight years. Further, the cooperative student's practical training has covered a broader field and his theory has been given many hitching posts in his mind. His groundwork is more amply and more thoroughly established.

A student's fitness for his chosen profession is much more easily judged under the cooperative system than under the regular system. His experience in actual engineering work and his contacts with other students in many different phases of training, give him a real picture of what engineering is, rather than one drawn from popular magazines and movies, with the subsequent disillusionment when the hard grind is faced.

A trained critical mentality is desirable, but if it lacks hard contact with life it frequently runs wild, errs in its conclusions, and sometimes becomes maudlin. Training in the constructive faculty gives it steadiness. Life becomes a search for the workable mean; a critical plus a constructive quest for the best answer attains the highest possible good. The cooperative system gives coordinated training and experience in both. For example, our discussions in the field of labor economics are held in the fifth year, prior to which time our students have been laborers, mechanics, and minor executives. A background of experience such as this adds immeasurably to the reality and the value of the discussions and to the critical judgments of the students on the theories presented. Similarly, in mechanical engineering, students who have worked on the various machine tools such as the lathe, milling machine, drill press, grinder, and so on, do not need to study a voluminous textbook to tell them what these machines can do and what their many parts are. Hence when the theories of machine design are approached in the third year, no long descriptive courses are necessary.

This conserves much curriculum time. In addition, the student engineer understands the introduction of the proper factors of safety necessary when theory must be expressed through materials and men.

Under the cooperative system, teaching the theory only (plus certain cultural courses) is the function of the school; teaching the practice of engineering is the function of industry. Practice can be learned only where the thing is practiced.

Finally, there is a by-product of the cooperative system which defies phrasing. To sense it, one must live with the system in operation. It is a quality that comes from being required to face the day's work squarely and successfully. It comprises the development of a silent strength of will combined with honest judgment rather than captious criticism. A freshman in a large organization or on the building of a bridge learns quickly how little he knows. He gets the value of clear-cut knowledge as against fluid generalizations. His perspectives begin to lose their distortions. He finds a new basis for the value of money in work done. But above all, he realizes that in engineering you don't evade the thorough doing of things—you can't "just get by;" you don't try to slide around a disagreeable but necessary task—you fool only yourself. The cooperative system teaches an engineer to do his best naturally and as a matter of course. Also it teaches him that you can't trick basic laws.

It is a good thing for a man to sweat his way toward the Truth.

NATIONAL APPRENTICESHIP UNDER WAY

By WILLIAM F. PATTERSON

FEDERAL COMMITTEE ON APPRENTICE TRAINING

FORTY-THREE states have set up administrative machinery to handle apprentice training. Thirty-five of these have drafted and have had approved comprehensive plans of operation. Apprentices are already working in forty different occupations in seven of these states. That is a "thumb nail" report of the status of the new Federal-State Apprentice Training Program. The salient features of this program are:

(1) A Federal Committee on Apprentice Training which guides, stimulates, and coordinates the program; serves as a clearing house of information; and interprets the minimum standards established.

(2) State committees on apprentice training which are responsible for organizing, promoting, and supervising activities.

(3) State and local trade advisory committees which develop training schedules and make recommendations to state committees on wage rates of apprentices, number of apprentices required in the trade, proposed papers of indenture, and similar related matters.

The underlying idea behind the program is that there should be minimum standards established by the Federal Government and that state and local agencies should be given a maximum of latitude in handling apprentice training.

The advantages to be derived from general national guidance are great. The observance of minimum standards by every state will mean that the diploma to be granted to graduating apprentices will have definite value and wide acceptability. An employer in Massachusetts will know that if an applicant holds a diploma from the California committee on apprentice training, as a graduate machinist's apprentice, he has had genuine training in all branches of his occupation. Such a diploma will be recognized as evidence that the holder has undergone a thorough training course on the job and in school.

Each state committee appointed by the Secretary of Labor must contain representatives of all groups most vitally concerned, particularly employers and employees. This will give to the program in each state a balance which is essential. The presence of a representative of the United States Employment Service on each committee will make more available to this committee the best information obtainable regarding those fields in which training is most needed.

I have spent a great deal of time the last six months working with these committees and have been impressed with the capability of the men and women serving on them, the interest which they evidence, and the harmony with which they operate. They are giving very liberally of their time even though they are all extremely busy. Their foremost consideration is the *welfare of the apprentice*. Extraneous controversial issues have not been permitted to enter into discussions in committee meetings.

To sum up their work very briefly, I may say that these committees approve apprentice papers submitted to them by employers. Recognition is made of the fact that employers who make work on the job an educational process are entitled to pay apprentices less than other workers during the first portion of the apprenticeship. The apprentice's wage graduates upward during the training period and is usually about three-fourths of the journeyman's wage when the training period is completed.

Apprentices under this program will receive related instruction in general and technical subjects through the public vocational schools. Vocational educators, through the United States Office of Education, state departments, and local vocational schools, play a major rôle both in developing and giving related education and in vigorously stimulating the adoption of apprentice training by employers.

This training program has met with unexpectedly wide employer acceptance. Among the reasons for this reaction on the part of employers, the following may be mentioned:

(1) The impending shortage of skilled labor is recognized.

(2) The advantage of a national program which will promote apprentice training in all states is appreciated.

(3) The fact that apprentice training will become universal among all employers in all states in an industry will mean that a comparatively small number of employers will not have to bear the brunt of training.

(4) Existing agencies are being utilized to promote the program; there is no extensive and costly governmental agency established to foster it. This also appeals to employers as a sound procedure.

One of the most gratifying indications of the colossal possibilities in the full development of this program has been the endorsement and assurance of support from nationally known industrial leaders, national code authorities, and national trade associations. Although many of these groups and individuals have been somewhat skeptical and suspicious before they fully understood the operation of the program, they have unanimously expressed themselves in favor of it after a complete discussion of every phase of its operation.

It is important to stress that this program is *in no way compulsory on employers*. Any employer can either elect to train his apprentices under present arrangements or can decide to do his training under the state committee.

What can employers or professional associations such as this do to be of tangible assistance to this movement? I have already obtained advice and definite help through personally meeting with your apprenticeship committee. Since that meeting the members of your committee have made valuable contributions to the direction of the national program and have acted as a catalytic agent in arousing the interest and activity of industry.

The staff of full-time workers on the Federal committee is so limited that intensive promotion with employers is out of the question. Hence, the Federal committee realizes increasingly that individual employers and trade associations will need to play a major rôle, not only in stimulating interest in organized training, but also in counseling relative to the mechanics of satisfactory apprenticeship activities.

With this in view, a series of meetings with national trade-association authorities is being held to urge each industry to designate a committee to formulate an acceptable program of apprentice training for each industry. Correspondence and personal contact with many of these groups indicate that they are willing and eager to cooperate in such a venture.

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As a striking example of what one industry is doing to promote apprenticeship, I should like to cite the following illustration:

The American Foundrymen's Association devoted a prominent place on its national convention program to a discussion of the new Federal-State Apprentice Plan. A few months later every employing foundryman in the country was provided with a bulletin reporting the discussion at the national convention. A joint committee of the American Foundrymen's Association and National Founders Association prepared and published a bulletin on standards of four-year foundry apprenticeship. This bulletin was supplied to all employing foundrymen in the country. A joint committee has secured the services of a man who will devote practically all of his time to the vigorous promotion of apprenticeship in this industry.

The office of the Federal Committee on Apprentice Training, located in the Department of Labor Building in Washington, will be glad to supply on request copies of a bulletin entitled, "What the Federal-State Apprentice Training Program Means to Employers" and other information regarding the apprentice plan. It will also be glad to place the names of all interested persons on its mailing list.

Comments, criticisms, and suggestions are invited in order that the program may be made a workable one.

The paradox of millions of young people unemployed on the one hand and a serious impending shortage of skilled workers on the other faces the United States today. This apprentice training program as fostered by the state committees on apprentice training can do much for the youth of the country, for industry, and for society at large by helping to create a body of skilled workers thoroughly competent to perform all the tasks comprising their occupation. Authorities believe that this movement will have a significant effect in developing an intelligent citizenry. Industry can and is cooperating to make the plan practical and successful.

[Since this paper was written the status of the Federal Committee on Apprentice Training has been brought into question by the Supreme Court decision. However, it is hoped that ways will be found to continue the work in progress in the various states.—EDITOR]

APPRENTICE TRAINING METHODS

By J. F. KOLB

NATIONAL METAL TRADES ASSOCIATION

THE transition from the period of the guilds to the machine age has introduced many factors which affect apprentice training, such as the gradual change from individual completion of jobs to participation in straight-line production. Recent developments introducing motion studies and other comparative measurements by engineers to secure maximum production with a minimum expenditure of energy compelling the use of the best standards of performance have affected apprentice training and have forced changes in methods.

The type of apprentice program considered in this paper embraces four years of well-rounded training in the fundamental operations or processes of the trade, including a sufficient variety of jobs on different machines or processes to avoid an early development of specialists of limited experience. Apprentices learning the machinist's trade would follow a general schedule for a three-year period. Their accomplishment during this period would indicate the probability of successful completion of the course as toolmakers, die-sinkers, machinists, or specialists in two or more lines. Apprentices who indicate adaptability would receive special training during the fourth year as toolmakers or die-sinkers. Another group, lacking ability to become toolmakers, would be given training in several activities during the fourth year to help them excel in two or more lines in addition to their general ability as all-around machinists. Others, who lack aptitude or ability to become toolmakers, die-sinkers, or general machinists, would be given further training during the fourth year in two or more activities in which they exhibited marked ability during the previous three years to develop highly skilled specialists in one or more processes.

For successful development of such a program management should carefully select the directing personnel to assure proper interest, aptitude, and attitude toward the activity and should then delegate to these individuals the responsibility of promoting and supervising the apprentice-training program. In large plants an apprentice supervisor serving as liaison officer should select apprentices, indenture, arrange for their transfer and advancement from one machine or process to another, give them the necessary instruction in mathematics, science, and drawing, and supervise the instruction given the apprentice in the shop on machines or processes by foremen. The supervisor should have an extensive, general, up-to-date experience as a toolmaker and machinist in addition to several years of college education, including educational psychology and theory and methods of teaching. One of the most important duties of the supervisor or official in charge of apprentice training would be to assist foremen to master the technique of teaching an apprentice, stressing adequate preparation and correct presentation to assure comprehension and correct application.

Management and foremen have often restricted training programs due to lack of confidence in the apprentice's ability to acquire certain knowledge and skills. Foremen have too often limited apprentice training to the more simple processes within the shop or neglected to instruct apprentices properly and later bitterly condemned apprentices and seriously criticized the quality of service former apprentices were able to render as journeymen when these failures should have been charged directly to the foremen's limitations.

The executives of smaller plants which must rely on foremen to train apprentices can secure more effective teaching results if they give their foremen a short intensive course on the teaching process. Every employee in industry would benefit, and increased earnings would result from such a course which would increase the efficiency of all employees. Foremen should be made to appreciate the almost limitless possibilities apprentices have for learning. The apprentice should be given the benefit of the doubt and should be thoroughly tested before his ability is questioned as to his mastering certain processes

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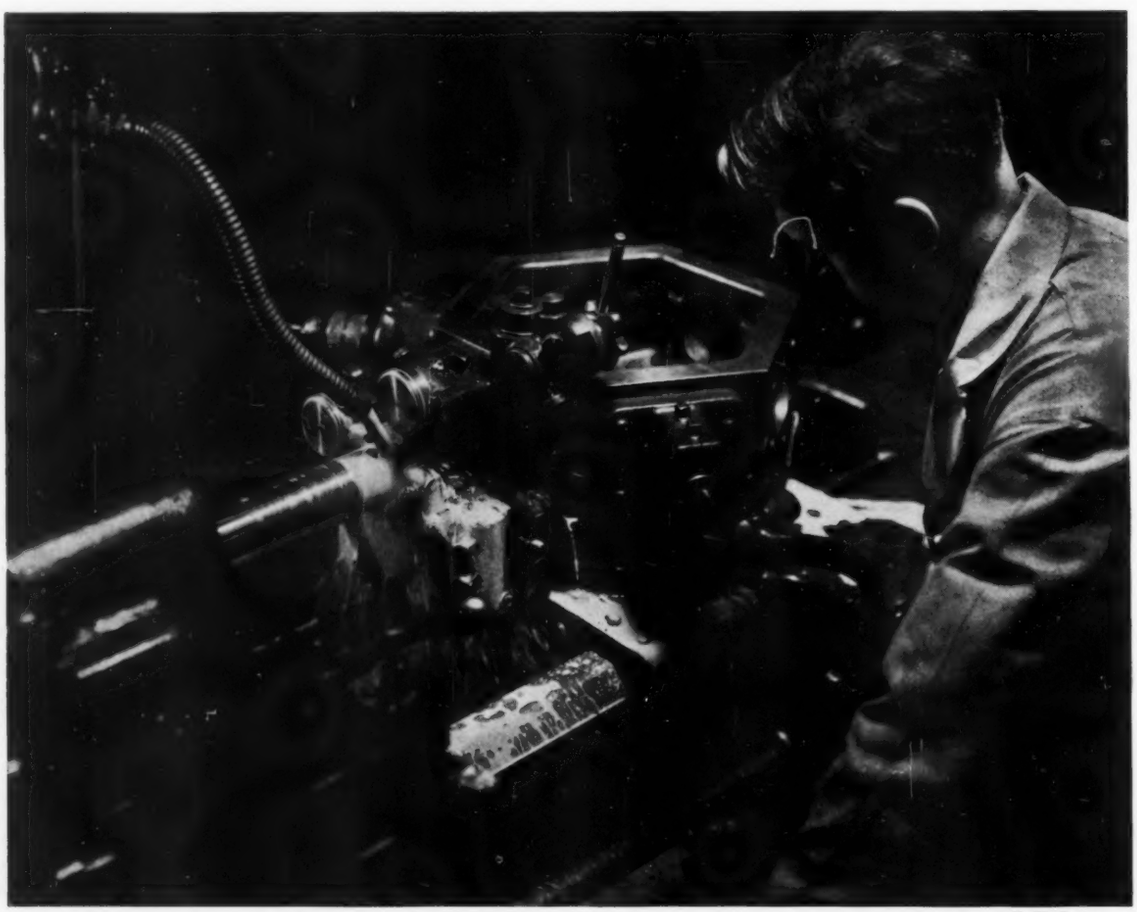
which are needed to assure his development as a skilled craftsman.

The methods employed should be modern and intensively applied directly to the individual in all shop and related subjects with instruction on the job when possible. Care should be exercised to teach correct motions and application of basic principles involved, showing the reasons for their use and special applications of these to assure a high degree of efficiency. Conservation of effort and materials through correct application of modern manufacturing methods should be taught in order to develop men who will be able successfully to meet the tests of modern highly competitive industrial conditions.

In addition to the older methods of personal instruction and demonstration, there is now available properly prepared printed material including complete analyses of operations or processes fully illustrated which indicates how each part of a job is done. Recently text material developed by a number of people has added to the recorded knowledge, experience, and technical information that were required for the completion of certain kinds of tasks. Most of these texts have been written by individuals and were prepared to meet definite needs. However, in many cases, because of a lack of time, training, and experience or facilities for collecting material and securing collaboration of many specialists in preparing it, texts have proved inadequate. The urgent need and insistent demand for better, more complete texts has induced manufacturers to have such material prepared by their agents. These agents have made comprehensive studies of needs and have developed suitable instructional material that is more complete as to subject matter covered and detailed instruction on tools or processes used in the trade than were available in the past. Contrasting the manufacturers' method of preparing the text material with the efforts of individual authors should be interesting because of the results obtained.

The manufacturers' agent selected highly trained, thoroughly experienced workmen to write the texts who were high-grade specialists on certain tools or processes. These manuscripts were submitted to approximately one hundred manufacturers who either manufactured or extensively used such tools. The manufacturers requested their plant managers, engineers, and foremen to check the material for general treatment, completeness of detail including illustrations and necessary applicable mathematics, and accuracy of text for each subject of instruction. The methods used and the extensive collaboration employed enable production of a superior type of instructional material that will improve effective in teaching and materially reduce the individual burden of the teacher and apprentice. The careful thorough organization of the instructional material has proved to be an effective means of helping foremen properly train apprentices at minimum cost. Men so trained should be more efficient than most craftsmen of today, and such an acquired mastery of tools and processes will develop in workmen a pride in craftsmanship that will be reflected in products that will extend our markets and bring richer rewards to manufacturers and craftsmen.



H. W. Forter

TAKING A $^{1}/_{2}$-IN.-DEEP CUT ON A $2^{1}/_{2}$-IN. STEEL BAR (S.A.E. 1020) AT 315 FT PER MINUTE SURFACE SPEED, REMOVING 42.4 CUBIC INCHES OF METAL PER MINUTE

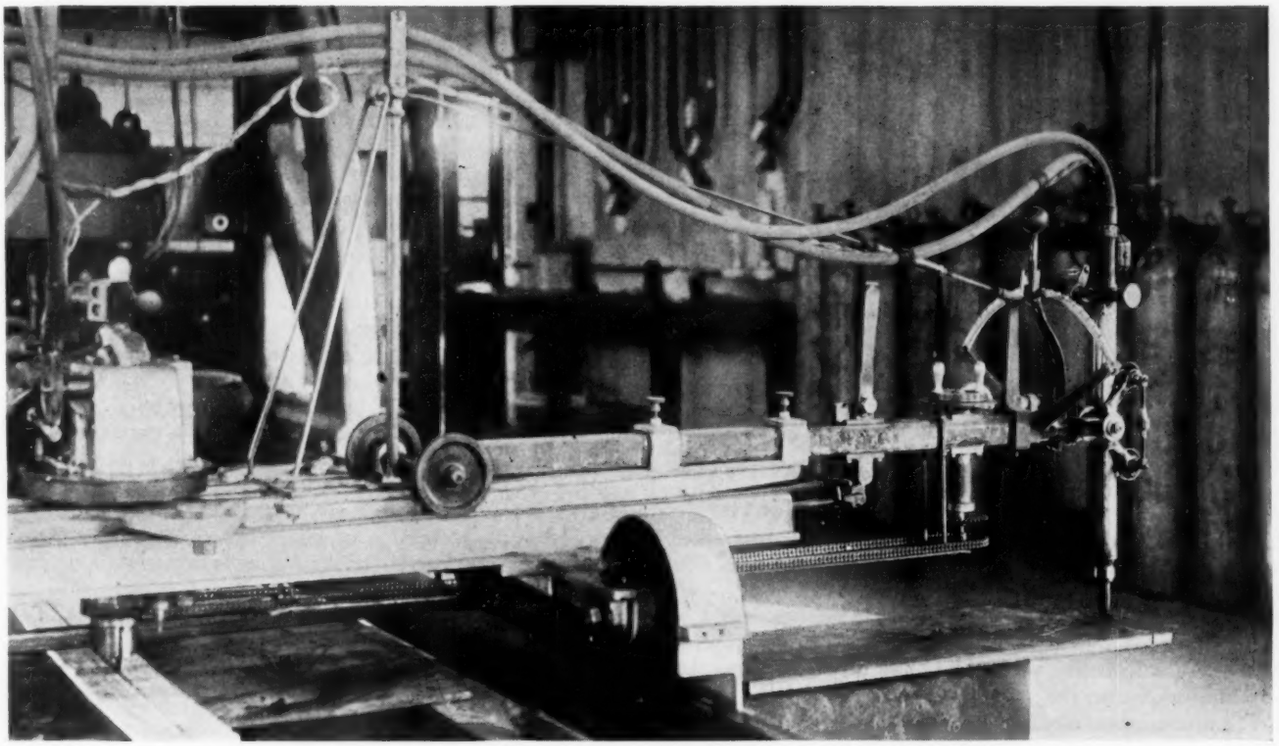


FIG. 1 PREPARATION OF MACHINE-FLAME-CUT SURFACE

CUTTING STRUCTURAL STEEL

A Comparative Study of the Effects on the Metal of Cutting by Friction Saw Shear, and Flame With Hand Torch and Machine

By J. H. ZIMMERMAN

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

THE purpose of this investigation was to determine as far as possible the effects of several of the more widely used methods of cutting structural steel on the properties of the metal adjacent to the cut surface. It is believed by some that in certain instances the failure of structural members may quite possibly have originated at the cut surfaces through damage caused by the cutting procedure and considerable more or less contradictory information pertaining to this subject has been published. It is hoped that the preliminary work here presented may to a certain extent clarify some of the more controversial issues.

Representative surfaces resulting from the five methods of cutting—machining, shearing, friction sawing, hand-torch cutting, and machine flame cutting—are shown in Fig. 2. It should be stated that the machined surfaces were used primarily as a basis for comparison. In each of the four remaining cutting procedures ordinary shop practice was adhered to as closely as possible.

The specimens employed in the comparative study of the cutting methods were all removed from the same $^1/_2$-in. hot-rolled structural-steel plate. Prior to the preparation of the test specimens this plate was carefully inspected and checked for any abnormalities which might contribute toward erratic results. None was found. The properties of the plate are given in Table 1 where complete conformity with A.S.T.M. Specifica-

TABLE 1 PROPERTIES AND ANALYSIS OF THE TEST PLATE AS COMPARED WITH A.S.T.M. SPECIFICATION A9

	Test plate	Spec. A9
Tensile Properties		
Tensile strength, lb per sq in.	61,400	60–72,000
Yield point, lb per sq in.	35,700	30,700
Elongation in 8 in., per cent	30.0	22.8 min
Cold-bend test, deg flat	180	180
Chemical Analysis		
Carbon, per cent	0.24	..
Manganese, per cent	0.46	..
Silicon, per cent	0.10	..
Sulphur, per cent	0.033	..
Phosphorus, per cent	0.017	0.06 (max)

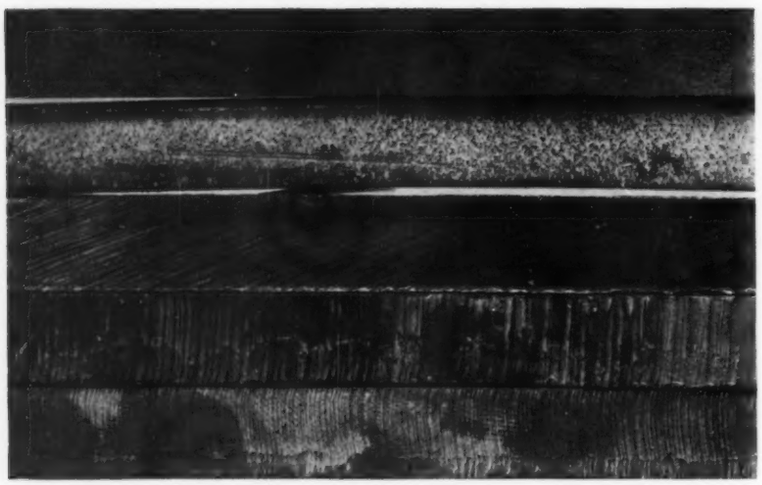


FIG. 2 APPEARANCE OF THE SURFACES RESULTING FROM THE FIVE CUTTING PROCEDURES UNDER TEST (FROM TOP TO BOTTOM: MACHINED, SHEARED, FRICTION SAWED, HAND-TORCH CUT, AND MACHINE-FLAME CUT)

tion A9[1] is indicated. The slightly banded structure is quite normal for steels of this type and it is believed that no variations in the results to be reported may in any way be attributed to anything other than the cutting procedure involved.

The investigation has been divided into four principal parts, namely, determination of the effect of cutting procedure on: (1) The hardness of the metal adjacent to the cut surface; (2) the microstructure of this metal; (3) the toughness or impact value of the surface metal; and (4) the ductility of the cut surface as measured by the cold-bend test.

HARDNESS TESTS

It is obvious that as far as hardness changes are concerned the principal effects of importance are likely to be confined to the region fairly close to the cut surface. Accordingly, a method of hardness exploration has been applied here that has been used with some success in determining the hardness penetration of nitrided and other case-hardened surfaces. This method consists essentially in preparing a specimen, one surface of which has been treated with the cutting procedure in question, and in the subsequent removal by extremely careful grinding of most of this surface with a taper of 1 in 25. It is possible by this means to measure hardnesses along the tapered surface at such distances between tests as to eliminate any effect of one indentation upon another, but at the same time actually to test the hardness at extremely small increments of penetration from the cut surface. The hardness specimens used for this investigation, together with a sketch indicating the method of preparation of the specimens, are shown in Fig. 3. Throughout the entire investigation of hardness the Vickers hardness-testing machine with a special indexing fixture has been employed. It is believed that the hardness numbers determined with this machine using a 10-kg load and the $^2/_5$-in. objective are strictly representative of the metal very close to the surface tested, if not at the surface. Readings have been taken at such distances along the tapered surfaces as to permit reporting of the hardness at depth increments of 0.002 in. The results of preliminary tests of the five surfaces indicated that in each case the original plate hardness has been reached before a depth of $^1/_2$ in.

In order more definitely to study conditions immediately adjacent to the cut surface a second series of hardness tests was conducted, the results of which are shown in Figs. 4 and 5. Considerable variation is seen to exist. It will further be noticed that the machined surface which was used primarily as a basis for reference exhibits a slight but quite definite surface hardening. This, however, has completely disappeared at a depth of only 0.002 in. from the surface and is of no significance other than to indicate the sensitivity of the method of testing. The results of all hardness tests are shown in Table 2.

The sheared surface shows a slightly irregular but gradually decreasing hardness for the entire $^1/_2$-in. zone investigated. The phenomenal surface-hardening effect of the friction sawing is extremely interesting, but this effect is seen to disappear, at least for the main part, in the first few thousandths of an inch. The lack of ductility normally accompanying a hardness of this magnitude might be instrumental in the promotion of minute surface cracks through relatively slight plastic deformations of the cut plate. Further consideration of Fig. 5 shows little difference in hardness as brought about by the two flame-cutting methods. In each case there is a certain surface-hardening effect which gradually decreases in a fairly uniform manner until the hardness of the plate stock is reached. A study of Fig. 5 will reveal the relatively mild hardening effects of the flame cutting as compared with the effects of shearing or friction sawing.

TABLE 2 EFFECT OF CUTTING ON THE HARDNESS OF METAL ADJACENT TO THE CUT SURFACE

Distance from surface, in.	Vickers Brinell Hardness				
	Machined	Sheared	Friction sawed	Hand flame cut	Machine flame cut
0	164	245	345	204	218
0.002	137	240	333	197	206
0.004	137	243	254	197	200
0.006	134	237	246	195	193
0.008	134	237	240	197	190
0.010	134	237	227	200	190
0.012	131	230	198	197	195
0.014	131	242	182	190	195
0.016	134	227	177	197	181
0.018	131	237	174	197	187
0.020	137	233	174	200	185
0.025	134	232	177	174	181
0.030	131	206	171	164	181
0.035	136	200	168	174	173
0.040	133	193	158	170	174
0.045	134	190	151	177	162
0.050	128	189	143	166	163
0.06	131	187	138	181	155
0.07	136	181	133	170	147
0.08	134	173	131	170	157
0.09	134	170	131	164	141
0.10	137	169	136	158	151
0.15	136	159	137	163	147
0.20	136	155	136	157	145
0.25	137	159	134	155	143
0.30	136	153	133	149	143
0.35	138	149	138	141	143
0.40	141	145	136	139	145
0.45	134	141	136	136	141
0.50	138	136	138	139	139
0.60	136	135	138	138	139
0.70	138	138	138	138	137
0.80	136	138	136	136	141
0.90	138	141	143	133	136
1.00	137	138	138	135	138

[1] American Society for Testing Materials, Standard Specifications for Structural Steel for Buildings.

MICROSTRUCTURE

The changes in structure as influenced by the various methods of cutting are illustrated in the photomicrographs included in Fig. 4. The plate structure as shown in the case of the machined specimens shows no effect of the machining despite the very thin layer of cold-worked material at the surface. In fact this may be considered to be a perfectly representative photomicrograph of the plate stock used throughout the investigation. The photomicrograph of the sheared surface is representative of the extreme condition, yet this structure showing the tremendous cold-working effected by the shearing operation is in no sense unusual. The sharp V-notch illustrated is an ideal stress concentrator, although it is unlikely that any crack formation or propagation will result due to the favorable location of the discontinuity with respect to any applied stresses.

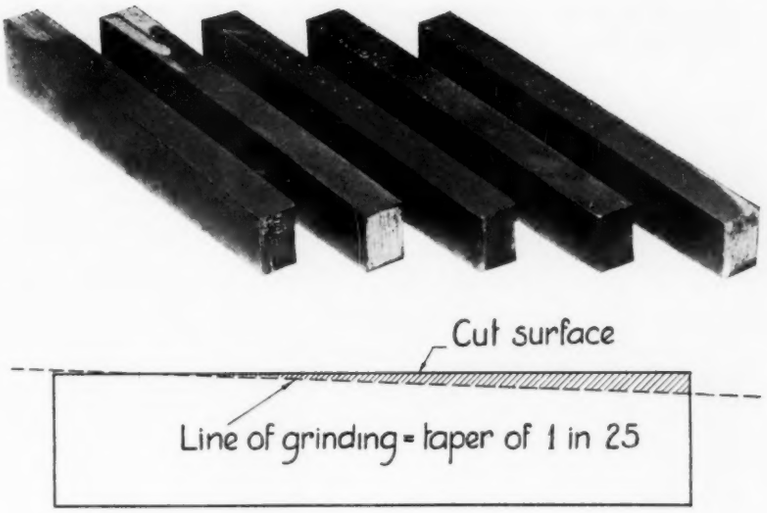


FIG. 3 HARDNESS TEST SPECIMENS AND METHOD OF PREPARATION

The friction-sawed surface discloses a somewhat unusual pseudomorphic structure in the first few thousandths of an inch adjoining the surface. The island-like constituent supported in a ferrite matrix has every appearance of the original pearlitic areas in the region adjacent to the normal structures, yet this arrangement fades into a structure which might easily be confused with that of a thoroughly spheroidized cementite. The extremely rapid self-quenching of the plate edge from a condition of complete or partial solid solubility has left a partially martensitic structure not clearly established by the photograph. The high local hardness of Vickers 345 is the result of the self-quenching action.

The hand-torch-cut surface shows the usual zoning effect with regard to grain size. The coarsened zone accompanying the overheating is, however, restricted to a very narrow band of a few hundredths of an inch after which the extremely fine layer is easily distinguishable. The carbon content of this surface is unquestionably higher than that of the normal plate metal and because of the quenching effects induced by the flow of heat to the adjacent plate metal the resultant structure is largely sorbitic. It is interesting to note the cleavage or Widmanstätten structure in the overheated section immediately adjacent to the flame-cut surface. It will be noted that the same general effects of the hand-torch cutting persist in the case of the machine flame cutting with the exception that the affected zone is confined to a more narrow band. The normal plate structure in this case has been only slightly disturbed at a depth of $^1/_{32}$ in. from the surface and the coarsened region is restricted to a layer of only a few thousandths of an inch in depth.

IMPACT TESTS

The specimen used for the impact tests was adopted, not with the idea that it was a perfect criterion of the toughness of the metal adjacent to the cut surface, but with the thought that it would give a fairly comparative measure of the general effect of each of the five cutting procedures on the normal toughness or impact value of the plate material. The transverse-type Charpy specimen employed is not symmetrical as far as cutting effects are concerned. It was necessary to adopt this specimen because of the obvious impossibility of cutting two sides of a specimen less than 0.4 in. square by any of the methods involved other than machining. It is felt that despite this lack of symmetry some effect of the cutting practice should be reflected in the impact resistance of the specimen, and it is apparent from the result shown in Table 3 that this is true.

The values obtained for the plate material as machined are perfectly normal with respect to magnitude and uniformity. It will be noted that the average of five individual tests has been used as a basis for comparison in each instance. The sheared specimens show some loss in toughness and the direction of shear is seen to have very little effect on the average impact value. In the case of the friction-sawed specimens there is again a slight drop in toughness. The incongruity between the

TABLE 3 IMPACT-TEST RESULTS

Specimen no.	Surface tested	Notched surface	Charpy transverse impact value, ft-lb, individual	average
1-1	Machined	Any	20.0	21.4
1-2			21.5	
1-3			21.8	
1-4			21.6	
1-5			22.1	
2T-1	Sheared	Top	17.6	17.2
2T-2			16.2	
2T-3			18.4	
2T-4			17.1	
2T-5			16.7	
2B-1	Sheared	Bottom	15.0	16.9
2B-2			17.1	
2B-3			17.1	
2B-4			18.6	
2B-5			16.8	
3-1	Friction sawed	Top	20.3	19.8
3-2			19.5	
3-3			20.0	
3-4			21.0	
3-5			18.4	
4T-1	Hand flame cut	Top	38.8	31.1
4T-2			22.3	
4T-3			39.4	
4T-4			35.4	
4T-5			19.4	
4B-1	Hand flame cut	Bottom	36.5	37.7
4B-2			47.1	
4B-3			22.4	
4B-4			38.9	
4B-5			43.6	
5T-1	Machine flame cut	Top	18.1	20.3
5T-2			21.8	
5T-3			16.4	
5T-4			20.7	
5T-5			24.7	
5B-1	Machine flame cut	Bottom	22.6	21.9
5B-2			22.6	
5B-3			20.7	
5B-4			18.6	
5B-5			24.9	

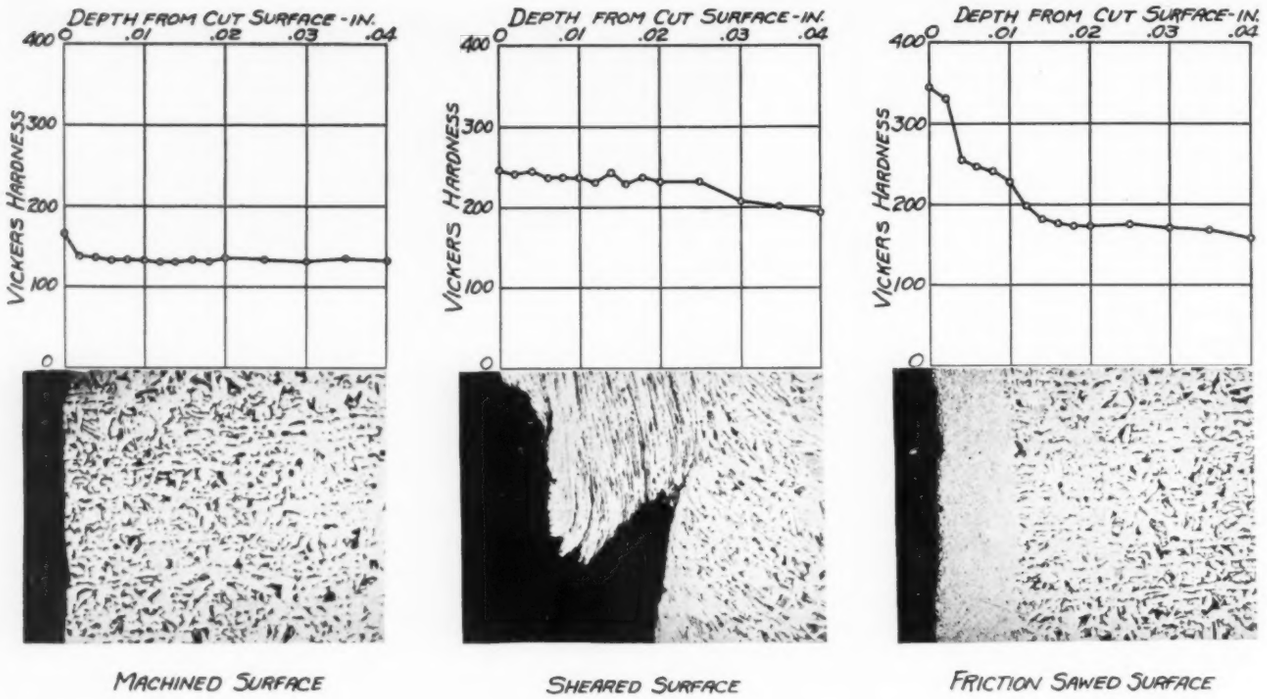


FIG. 4 EFFECT OF THE FIVE CUTTING PROCEDURES ON THE SURFACE HARDNESS AND MICROSTRUCTURE OF THE TEST PLATE

high hardness for this surface and the small decrease in toughness can be explained by the relatively thin superficial layer of hardened material with respect to the large volume of undisturbed metal. The results for the hand-torch-cut specimens vary between the toughness of the parent plate and twice this same value to give a comparatively high average. The average of the five specimens which were notched at the top of the cut surface show approximately 50 per cent increase over the plate metal and the second series of hand-torch-cut specimens shows an even higher figure. A comparison of the results for the two series of torch-cut specimens shows the metal adjacent to the top or torch side of the cut to be somewhat tougher than the corresponding metal at the bottom side of the cut. This is probably due to the greater heating of the upper surface and the subsequently deeper penetration of the quenching action. The irregularity of these results is unquestionably largely due to the notching effect of the hand-cutting procedure. In the case of the machine-flame-cut specimens very little change in the toughness has been found. The slight decrease from the normal plate value is probably negligible and certainly in no sense serious. Further study of machine-cutting procedure toward the incorporation of some of the toughness inherent in the hand-flame-cut surface is indicated. Again in the case of the machine-flame-cut impact tests, we find the metal at the top surface of the cut plate to be slightly tougher than that at the bottom, presumably because of a slightly greater heating and quenching effect.

COLD-BEND TESTS

The cold-bend tests were conducted on specimens cut from the original $^1/_2$-in. plate by the method under test. Two series of specimens were obtained, one with the direction of rolling longitudinal, and the other with the rolling direction transverse. In those cases where the direction of the cutting might

TABLE 4 RESULTS OF COLD-BEND TESTS

Specimen No.	Type of cut	Direction of rolling	Edge of cut in tension	Angle of bend about 1/2-in. pin	Appearance after flattening
1-1	Machined	Longitudinal	Either	180	No cracking
1-2		Longitudinal	Either	180	No cracking
1-3		Transverse	Either	180	No cracking
1-4		Transverse	Either	145	Cracked
2-1	Sheared	Longitudinal	Top	95	Cracked
2-2		Longitudinal	Bottom	95	Cracked
2-3		Transverse	Top	60	Cracked
2-4		Transverse	Bottom	55	Cracked
3-1	Friction	Longitudinal	Top	90	Cracked
3-2	sawed	Longitudinal	Bottom	90	Cracked
3-3		Transverse	Top	80	Cracked
3-4		Transverse	Bottom	70	Cracked
4-1	Manual	Longitudinal	Top	180	No cracking
4-2	flame cut	Longitudinal	Bottom	150	Cracked
4-3		Transverse	Top	100	Cracked
4-4		Transverse	Bottom	55	Cracked
5-1	Machine	Longitudinal	Top	180	No cracking
5-2	flame cut	Longitudinal	Bottom	180	No cracking
5-3		Transverse	Top	180	Cracked
5-4		Transverse	Bottom	170	Cracked

possibly influence the cold-bending ductility, a bend in each direction has been made; hence the bend-test results include for each surface four specimens, the results of tests of which are shown in Table 4. The bend tests were conducted in the cold-bend machine by wiping the specimen around a pin 1/2 in in diameter until appreciable corner cracking had occurred. The corners of these specimens were not rounded as is customary in preparing cold-bend test specimens in order to intensify any effects of the cutting on the ductility of the cut surface. The test results for most specimens are expressed in terms of the angle of bend to produce cracking. The specimens which satisfactorily withstood a bend of 180 deg around the 1/2-in. pin were subsequently flattened between compression heads. In Fig. 6 are shown the five specimens which satisfactorily withstood complete flattening without cracking.

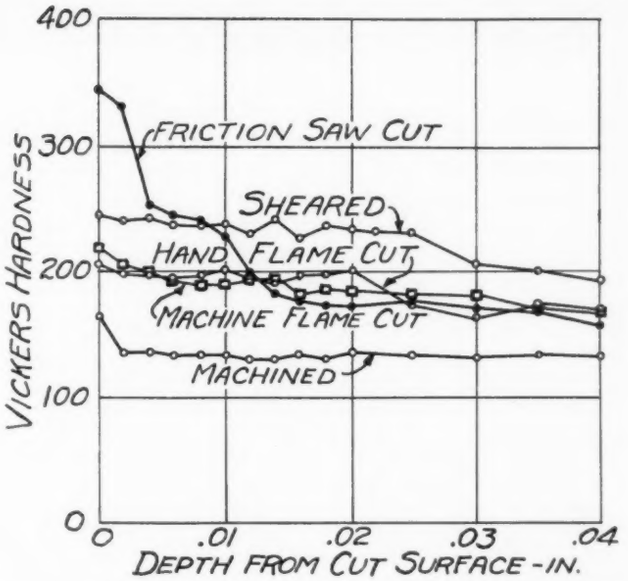


FIG. 5 COMPOSITE CHART OF THE SURFACE HARDNESS EFFECTS INDUCED BY THE FIVE CUTTING PROCEDURES

SUMMARY

The illustrations and tables accompanying this report summarize the findings fairly completely and no attempt will be made to draw rigid conclusions from this preliminary study. In general the tests have shown:

(1) The disturbance of the hardness and structure of the structural-steel plate tested is less severe in flame cutting than in either shearing or friction sawing.

(2) Machine flame cutting does not appreciably affect the toughness of the metal adjacent to the cut surface, hand-torch cutting definitely improves the toughness of this metal, and shearing or friction sawing decreases the toughness slightly.

(3) Ductility of the structural plate tested, as determined by the cold-bend test, is less seriously affected by hand-torch cutting than by either shearing or friction sawing. Machine flame cutting may even be beneficial in this respect.

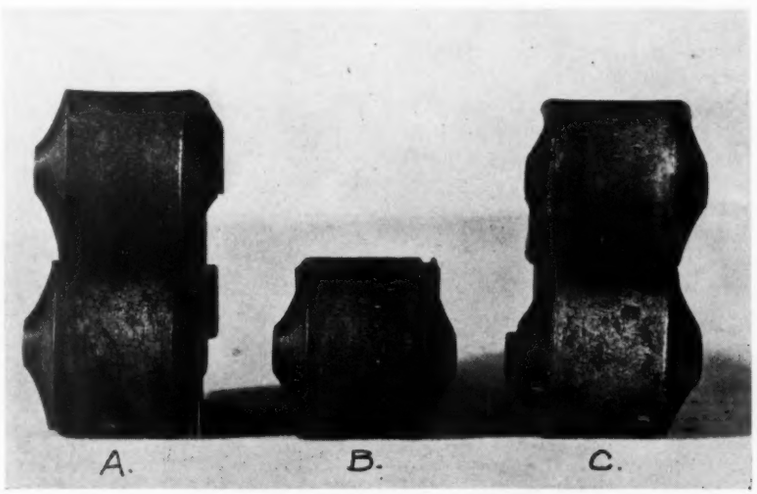


FIG. 6 THE FIVE COLD-BEND SPECIMENS THAT SATISFACTORILY WITHSTOOD A BEND OF 180 DEG FLAT (*A* = MACHINED, LONGITUDINAL ROLLING. *B* = MACHINED, TRANSVERSE ROLLING. *C* = MACHINE-FLAME CUT, LONGITUDINAL ROLLING)

N.A.C.A. LANGLEY FIELD CONFERENCE

THE N.A.C.A. held its annual conference at the Langley Field, Virginia, laboratories on May 22. As usual the conference was attended by a notable group representing the aviation industry, the Army Air Corps, the Navy Bureau of Aeronautics, and the Air Commerce Bureau. The universities interested in aeronautics were not represented, as, strange to say, no invitations are issued to the schools, although their graduates naturally provide the major part of the Langley Field Conference. The results of experimental work carried on during the year were presented to visitors in a main meeting, in a series of subsidiary conferences, and by carefully organized visits to the laboratories. Even the new science of aeronautics must bow to the law of diminishing returns, and while solid contributions to knowledge have been made by the Committee, no startling discoveries or innovations were made public.

The most interesting addition to the equipment at Langley Field was in the form of a vertical free-spinning tunnel. Air is drawn up through a vertical cylinder some 27 ft long and 15 ft in diameter at speeds varying between 15 and 50 ft per sec. A small model lightly built of balsa wood, and with weight and moment of inertia distributed so as to simulate the full-scale airplane, is introduced into the tunnel at the end of a long pole, with the rudder set for a spin. When the model is spinning freely in the air stream, the pole is withdrawn and the model hovers in a condition exactly simulating full-flight spin conditions, with the upward velocity of the air replacing the vertical velocity of descent in the spin. A clockwork mechanism built into the model, actuates the rudder or elevator against the spin. If recovery takes place, the model passes from the spinning nose dive into an ordinary dive, and is caught in a net mounted below the working section of the tunnel. The phenomena are observed from a platform either visually or by means of a moving-picture camera. Here is a practical tool for the airplane designer which will tell him at far less hazard than in a test flight, whether or not his aircraft will recover. To the British Royal Aircraft Establishment is due the credit of having built such a tunnel for the first time in 1930, and it is gratifying to know that such apparatus is now available to American aviation.

At no time has so much attention been concentrated on improvement of planes for private flying, and Langley Field is collaborating in this endeavor by attacking the problem of lift-increase devices and means for lateral control. The Fowler variable-area wing, in which a rear under portion of the wing slides out rearward, increasing both the area and the effective camber of the supporting surface, was the subject of experimental and theoretical investigation. While the split flap or air brake, now almost universally employed on our air lines, has shortened the glide-in over an obstacle and the subsequent landing run, it does *not* improve the take-off run and subsequent climb over an obstacle. The extension of the wing means an increase in the lifting capacity, without a correspondingly high increase in drag. Hence the Fowler wing *does* improve take-off characteristics and so is likely to be useful both for the private plane and for Navy deck-landing airplanes.

A new spoiler aileron was presented in which a spoiler or flat surface is offered to the wind on one side of the wing. This decreases the lift so that the spoiler acts as an aileron. The drag of the wing is also increased, so that the spoiler-aileron works with the rudder instead of against the rudder as in more conventional ailerons. The new spoiler also opens a slot through the wing, thus eliminating aerodynamic lag which has been a drawback in previous spoilers. Another advantage of the spoiler is its location in the forward part of the wing; the rear flap or air brake can thus be carried to the extreme tip of the wing, and not cut short and made less effective as is the case with conventional ailerons. The utility of this device in private plane design is obvious.

Aerodynamic refinement is still being carried further, step by step, with better cowlings of the engine and better positioning of the wing relative to the fuselage.

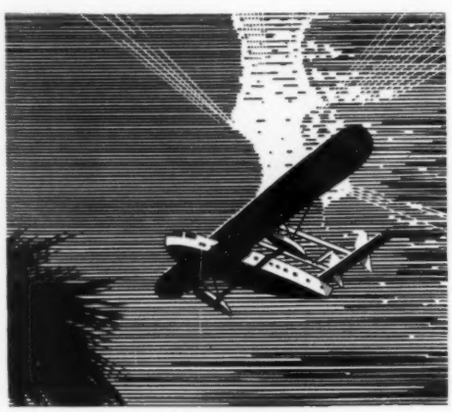
The distinguished gathering was given a striking demonstration of the direct take-off autogiro. An autogiro rotor, mounted on a vertical cable, with a cable attached to the upper end of its axis of rotation was speeded up to 150 per cent of its normal rpm, by a vertical electric motor, then a clutch was released and the rotor rose merrily into the air. The direct take-off autogiro is one of the most significant events of recent years, and the demonstration brought home the universal possibilities of the new design.

Fuel injection is gradually being brought to the standards of power of the carbureter engine. Greater fuel efficiency than is possible with the carbureter engine has already been attained, and the possibility of using a heavy non-inflammable fuel oil in an aircraft engine is a most enticing one. The two-cycle engine work of the Committee is also most interesting. Combined with fuel injection the two-cycle engine comes finally to practicability, since fuel need no longer be lost during scavenging.

Propeller vibration is engaging much attention. Vibration, simple in elementary theory, is one of the hardest problems to solve in high-speed aircraft. The Committee's view is that propeller vibration is a matter of dynamics alone, without regard to aerodynamic flutter—an opinion from which many authorities strongly dissent.

The question of scale effect on airfoils is approaching solution, thanks to the facilities for comparison in the atmospheric tunnels, the variable-density tunnel, and the full-scale tunnel, all available at the field.

The towing basin is actively at work, and is giving designers the definite frictional information which engineers love so much. That the world does move was proved by the comparative test of the NC float used by the Navy in its early trans-Atlantic flight, with a modern float. For the same aircraft and horsepower, take-off time and speed were reduced to nearly 50 per cent of the 1921 figures.



These are but the "high-spots" of the huge program presented. Even a well-informed gathering, though highly grateful, complained of severe mental indigestion.—A. KLEMIN.[1]

[1] New York University. A.S.M.E. Representative at Langely Field Conference.

MODERN CAST IRON

By R. G. McELWEE

ECORSE FOUNDRY CO. ECORSE, MICH

IN DISCUSSING this subject it is my intention to present it in such a manner that engineers may be guided in getting the very most in the way of physical properties in writing specifications for the new cast iron, to familiarize them with the effects of processes that are more potent than materials in their influence and final results, and to expose some commonly accepted fallacies regarding foundry practice.

In purchasing cast-ferrous materials, to attain certain specific results, it should be borne in mind that it is highly important to select the foundry specializing in the particular type of casting required. Just as you take a broken spectacle lens to the optician for duplication, you should be able to take to your foundryman for duplication, a piece of casting showing the microstructure of iron successful in your work. The field for gray-iron castings is rapidly increasing, because it has been found possible to control the various steps in the manufacture of iron castings so as to produce definite guaranteed physical properties. This means that it has been possible, through more scientific melting and control methods, to duplicate certain microstructures.

MODERN FOUNDRY TECHNIQUE

It is now possible to melt at definite temperatures, and at temperatures much higher than were previously obtainable, and to do so under atmospheric furnace controls which enable us to calculate a definite analysis and be reasonably sure of attaining that analysis. Better cupola controls are available for steady jobs; but for small tonnage of special irons, electric-furnace iron seems to fill the need.

Another field developed only recently and not to its fullest extent is the mechanical control of cooling rates, melting and pouring temperatures, and other factors affecting the final condition of the casting which must be carefully controlled in order to produce consistent results. It has been the practice in certain industries to order cast iron by writing a chemical specification. Some large foundries built to produce a definite casting or castings in large volume have minimized these problems because the cooling rate and the melting temperature can be more accurately controlled where there is a steady flow of material from a melting unit properly synchronized with conveyers so that each step of each operation requires approximately the same length of time. Thus in many respects a large production of a single part offers less of a problem than a smaller quantity of that same part. Blueprints were sent to several foundries for estimate, and when the job was finally let the foundryman was told that he had to make the casting with a definite amount of total carbon, silicon, manganese, phosphorus, and sulphur, and, in some cases, alloy additions were specified also. It is safe to assume that if six patterns were exact duplicates and given to six different foundries, and if each foundry came well within the limits set for chemical analysis, then six different sets of physical properties would be obtained. It is just as important to control melting temperature, pouring temperature, time between pouring and shakeout, and time of adding alloys or metalloids, as to control the chemical analysis in the melting processes.

For example, the ability of silicon to graphitize depends largely upon the time at which it is added to the iron. It is possible to make castings of identical analysis in the one case by bringing out a spout mixture of a certain amount of silicon, all of which has been added to the charge, and in another by adding from 0.10 to 0.15, or even more per cent, of ferrosilicon resulting in the same total. In this case, however, it would be reasonable to assume that the Brinell hardness might be from 20 to 30 points lower than where the ferrosilicon was not added.

The writing of specifications for physical properties seems to be an improvement over writing chemical specifications only, but apparently there are also dangers in doing this unless due consideration is given to the type of iron being produced by the bidders. Hardness may be secured in the better grade of iron by increasing combined carbon just as in steel practice. This control of the amount of combined carbon in cast iron is more or less familiar to every foundry. It is sometimes difficult to produce uniform hardness without extremely hard spots, but it can be done with carbon alone, i.e., without alloys, and with proper control any reasonable hardness specification can be met. Too much cannot be said about the necessity for proper carbon-silicon balance, regardless of the melting method used. For that reason it is quite essential that the laboratory control of a certain mixture for a certain purpose be given careful study with this ratio in mind.

However, the fact that a casting shows a certain Brinell is not necessarily an indication that the type of hardness desired has been obtained. For instance, excessively high phosphorus will produce a phosphide which foundrymen call steadite. It is extremely hard and brittle—in fact, considerably more abrasive than the cementite or iron carbide which imparts the hardness to the better grades of cast iron. In certain cases from a foundryman's standpoint it is quite desirable to produce this hardness with phosphorus rather than carbon, because phosphorus lowers the freezing temperature of the iron and at the same time imparts apparent fluidity, which makes it much easier to produce castings of light section.

While it is generally true that wear resistance is directly proportional to Brinell hardness, it is not always so. Tests have been run which prove that irons as low as 170 Bhn may, in certain cases, outwear two to one other irons of 192 Bhn. The tests referred to were run on an Amsler machine, the disks being of the same material and were run dry. This may not indicate that the same results would be obtained if the tests had been run on disks of dissimilar material properly lubricated. It indicates that it is probably desirable to run a test, meeting as closely as possible the conditions encountered in service.

The method of melting has much to do with the results obtained, even with a specified analysis. Temperatures above ordinary cupola temperatures of approximately 2750 to 2800 F, have a profound effect on the resulting casting. It has been generally thought that at somewhere above 2900 F practically all of the carbon goes into chemical solution in the iron, and that in cooling to the freezing point and in freezing there are no nuclei provided around which graphite particles will crystallize. As a result superheated irons are apt to cool and freeze with a higher combined carbon and the formation of a much finer graphite. Hence it is possible to make a comparatively low-carbon iron which under high-temperature melting condi-

Presented at a meeting, Detroit, Mich., Nov. 22, 1934, of the Detroit Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

tions will show extreme hardness, and this iron can be much improved for machinability and for practical use by assisting graphitization by the addition of some material which provides the nuclei necessary, such as silicon, nickel, titanium, and other alloys.

In spite of the fact that the nuclei theory just discussed has been questioned and is not generally accepted by many metallurgists, the fact remains that superheating of irons under certain atmospheric conditions will produce, with the same chemical analysis, a finer grain size and a harder material, although the additional hardness cannot be accounted for in all cases by an increase in combined carbon. The use of titanium from the list of graphitizers mentioned seems to have some virtue in the fact that the resulting mixture has less tendency to chill. In other words, as a graphitizer, titanium used in the manner described, makes the material less sensitive to the rate of cooling, and it is thereby possible to produce dense iron in a heavy section with little tendency toward chill in the lighter section.

HIGH-MELTING IRONS

There are several arguments in favor of melting high-test irons by some means other than the cupola. The electric furnace has been chosen in many cases because it offers a higher degree of heat, a much better furnace atmosphere (by proper operation the atmosphere should be almost inert), and actual melting takes place much more slowly. The actual melting of the iron in the cupola is very rapid when the charge has fallen to the melting zone, whereas in the electric furnace the batch is brought up to heat rather slowly, promoting much better dissipation of all of the elements throughout the entire charge. Therefore, segregation is much less likely with this method of melting.

Moreover, the effect of the variable in electric-furnace melting of relative humidity of atmospheric air is eliminated. When it is considered that from 25,000 to 30,000 cu ft of free air are blown into the cupola blast to melt one ton of iron, the effect of the difference in moisture content from day to day on melting conditions can be imagined. This is particularly true in the making of small intricate castings, such as piston rings, although it probably affects all castings more than is realized. In fairness to cupola operation it should be stated that means have been found for weighing the air blast for drying it to a desired humidity so that it is now possible to produce a chemical balance between the oxygen blown into the stack and the carbon in the fuel and the iron which complete the chemical reaction. However, this fine degree of control is only possible where the melting rate is fairly constant and where the same type of material is being produced consistently. Some of these finer control mechanisms are not entirely adaptable to a jobbing foundry.

We must assume that in attempting to produce an iron for a specific purpose the foundryman is attempting to arrive at a definite relationship between the various constituents of cast iron in order to produce a given microstructure. In most cases this can be accomplished in one of two ways: (1) By adding certain alloys which have a chemical, or possibly a mechanical, effect in the molten state, and (2) by producing a casting having an entirely different microstructure from the one aimed at, followed by an annealing or other heat-treatment process to obtain the structure finally desired. There are reasons to believe that the latter process has much to offer, inasmuch as it is possible to deal with microstructures in a wide variety of sections, whereas the additions of alloys to produce a definite structure usually leads to the difficulty that the results in heavy and light sections are entirely different. It is also true that the heat-treatment method has so far given greatly superior properties, and therefore that field seems most worthy of development.

As a specific case: It is possible to produce a casting which is entirely unmachinable in the as-cast condition, and it is entirely feasible to heat-treat this casting to produce all ferrite with a Brinell hardness of 130 to 140, elongation of 10 to 12 per cent, and tensile strength of about 55,000 lb per sq in. This is malleable iron. The annealing takes less than 24 hours. It is also possible by a different method of heat treatment to produce, in this same casting, an almost pearlitic structure containing some globular graphite, called "temper carbon." The tensile strength without alloys will run from 90,000 to 100,000 lb per sq in. ultimate with an elongation approximately 4 to 5 per cent, and Brinell hardness of approximately 228.

Obviously, because of the pearlitic structure, this latter iron should be used in all cases where wear resistance is required. The ferritic iron, which is in fact malleable, like all other malleables of the same type, will not show good resistance to wear. The ferrite grains tear out and score; and particularly in brake drums it has been quite definitely proved that even quite small amounts of ferrite will give trouble from this standpoint.

We have been taught, and properly, that in designing castings we should attempt to keep the sections as nearly uniform as possible. While we are not ready to back down from this stand at the present time, a technique of producing castings with titanium as an alloy has been developed in which sections varying as much as from $^3/_{16}$ to 1 in. have been successfully cast with no change in Brinell hardness in any section. The heavy parts of these castings show exceptional soundness, just as would be expected if the iron had been calculated for that part of the casting. We are not ready to expound the theory because frankly the matter is more a case for conjecture than sound logic, but we do know from experiments that it is even possible to go far enough to reverse the conditions ordinarily expected and make the light section of the casting softer than the heavy section. This indicates the possibility of more economical design because sections can now be used as the engineer would like to use them, without the danger that the foundry will not be able to make the casting after it has been designed.

Much has been done recently with extremely high alloy values to produce very unusual results, a specific instance being the use of chromium in percentages of 17 to 35 to produce an austenitic iron which will resist heat and corrosion. This iron, while not readily machinable, can be annealed, and in the annealed condition can be machined with good tools. For the purpose for which it has been prescribed it seems to fill a vital need.

MORE COMPLETE SPECIFICATIONS

The foundry industry would like to be in the position of an apothecary, taking the prescription of the engineer and producing for him that structure and that casting which will best serve his purpose. To do this it may be necessary to include in specifications some other factors than those ordinarily used. It may be necessary to know, for instance, the highest temperature at which iron is stable, which will give an indication of its resistance to heat, the "weldability," a description of the microstructure, the elastic limit, deflection, ultimate strength, transverse strength, shearing strength, impact strength, endurance limit, in some cases permeability, resistance to various kinds of corrosion, modulus of elasticity, creep, and other factors which affect the foundryman only, such as temperature of freezing, shrinkage, and chill. It is by making the foundryman completely familiar with all of the conditions under which the casting will be used that the ultimate result from gray iron castings will be obtained.

The ENGINEER *and* HIS SOCIETIES

By HUBER O. CROFT

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THE present era is one of extensive inquiry. On every hand and from every corner we hear pertinent and uncomfortable questions, not only concerning the prevailing distribution of wealth and representative government, but also as to our systems of education, the policies of churches, the value of gold, and the importance of international trade. It is small wonder, then, that engineers living in turbulent political times should likewise reexamine their responsibilities toward their nation, their communities, and their chosen profession. In any critical examination of the professional responsibilities of an engineer one eventually comes not only to the question of the utility of our engineering societies in promoting the aims and broader aspirations of the individual engineer, but also to the type of engineering organization best fitted to fulfil and satisfy the demands of the individual. It is to the organization of engineering societies that this brief paper is devoted.

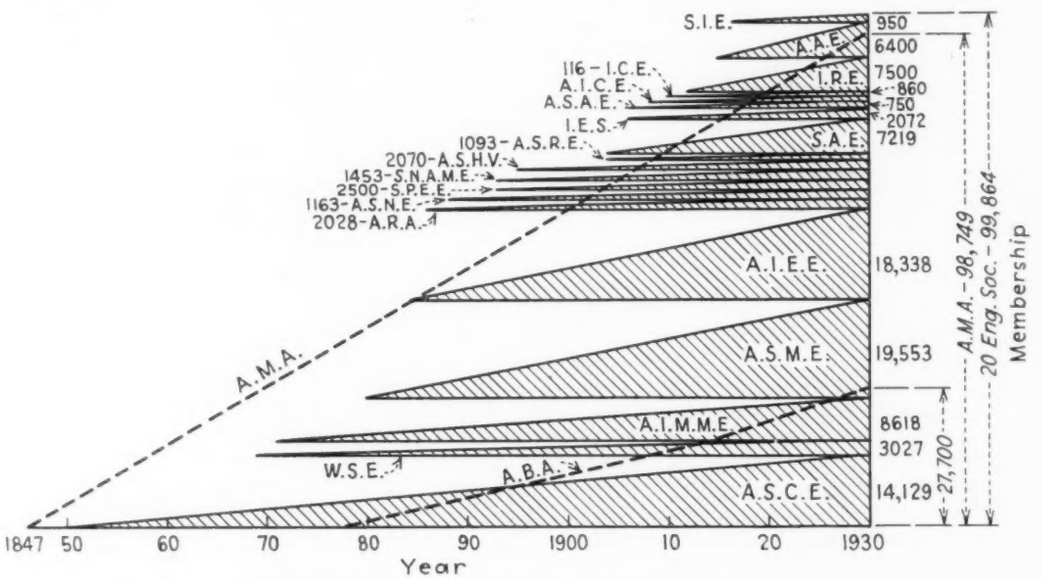

FIG. 1 DATE OF FORMATION AND NUMBER OF MEMBERS OF TWENTY OF THE NINETY NATIONAL ENGINEERING SOCIETIES

(The organizations shown beginning at the bottom are: American Society of Civil Engineers, American Bar Association, Western Society of Engineers, American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, American Institute of Electrical Engineers, American Railway Engineering Association, American Society of Naval Engineers, Society for Promotion of Engineering Education, Society of Naval Architects and Marine Engineers, American Society of Heating and Ventilating Engineers, American Society of Refrigerating Engineers, Society of Automotive Engineers, Illuminating Engineering Society, American Society of Agricultural Engineers, American Institute of Chemical Engineers, American Institute of Consulting Engineers, Institute of Radio Engineers, American Association of Engineers, American Medical Association, and the Society of Industrial Engineers.

Many important engineering societies have been omitted from the foregoing list because of the lack of time to obtain the required information. Most of the enrolment figures given are for the year 1929.)

MORE THAN 90 NATIONAL ENGINEERING SOCIETIES

We, as engineers, are prone to express ourselves with humorous quips when discussing some of the present governmental agencies which are identified by means of symbols such as AAA, FFMC, and TVA, but after all there are only 65 such alphabetical organizations to deal with 125 million individuals. Engineers will be interested to learn that there are at present more than 90 national engineering organizations to represent perhaps two-hundred thousand engineers. It would behoove the engineer, then, to devote at least part of his effort to simplifying his own alphabetical, professional porridge before he specifies a simpler recipe for our national alphabetical soup.

To illustrate the state of engineering affairs, Fig. 1 has been prepared. It reviews the development of some twenty engineering organizations. The horizontal scale is time and the vertical scale is membership. For example, the A.S.C.E., founded in 1852, has approximately 15,000 members enrolled at the present time.

For purposes of comparison the American Medical Association, A.M.A., and the American Bar Association, A.B.A., are also shown. It is interesting to note that the A.M.A. has a membership which embraces almost the same number of individuals as the twenty engineering organizations shown.

In considering Fig. 1, it should be remembered that practically every one of our national engineering societies has an excellent and extensive organization. It is apparent that there must be an overlapping and duplication of activities of the various groups, not to mention clashes of individual commit-

Presented at the annual convention of the Iowa Engineering Society, Des Moines, Ia., February 7, 1935.

tees attempting to accomplish the identical purpose, but each zealously jealous of obtaining the prestige when the objective has been obtained.

The story of the excitable Civil War general, who, when informed that the "zero hour" of attack was at hand, immediately leaped on his prancing charger and "rode off at once in

FIG. 2 AN ENGINEER IS ORGANIZED

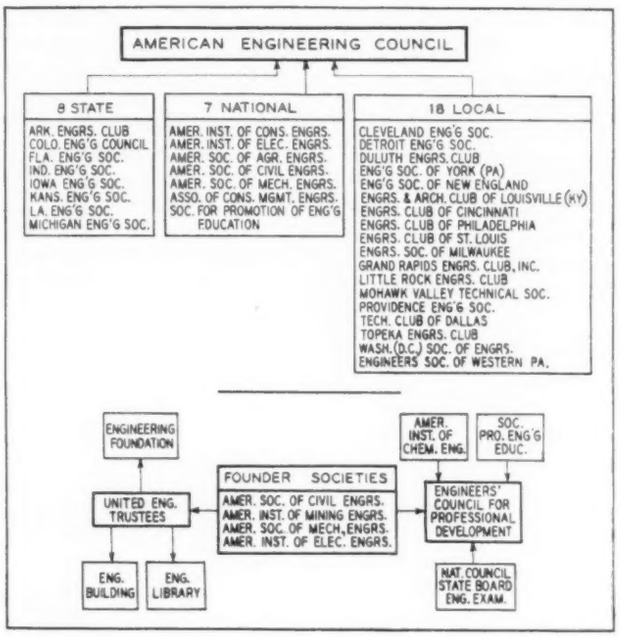

FIG. 3 PRESENT COORDINATION OF ENGINEERING SOCIETIES

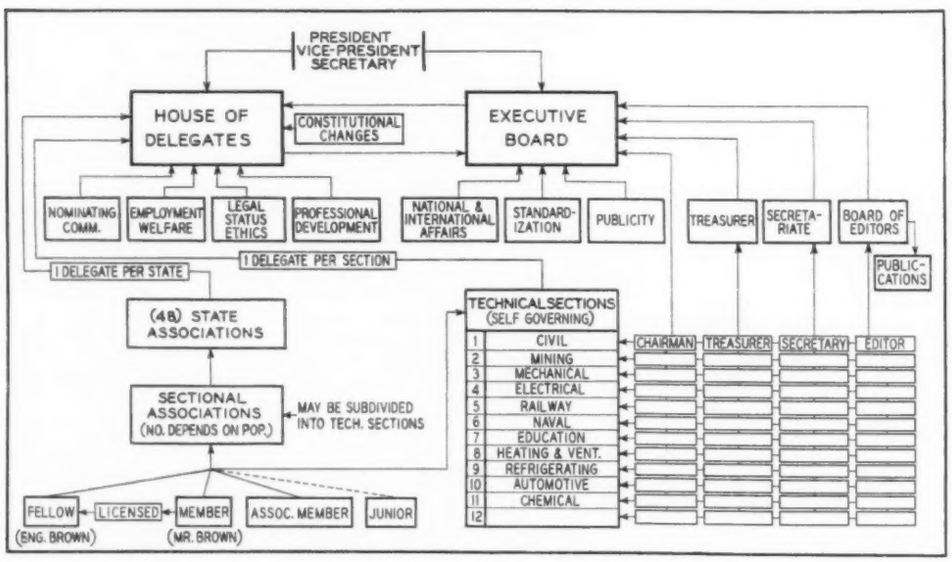

FIG. 4 A PROPOSED ORGANIZATION CHART FOR A NATIONAL ENGINEERING SOCIETY

all directions"? is a comparison apropos of the present organization of engineers with the exception that our profession is represented by ninety generals and ninety highly bred and nervous steeds.

HOW THE INDIVIDUAL ENGINEER IS AFFECTED

The effect of this confused state of affairs upon the individual engineer is demonstrated graphically by Fig. 2. The heavy circle in the center represents "me" surrounded by the four existing engineering societies to which the individual would prefer to belong for technical reasons. An outer circle of society activities is covered by a connecting link with each society. This outer circle of activities may be taken as typical, by and large, of engineering societies. The resulting confusion caused by four organizations attempting to give individual service in all activities is apparent.

Some societies, such as the Founder Societies, have stressed the left half of the activities circle, labeled "psychic interest," with little attention to the right half labeled "material interest." Other engineering societies such as the American Association of Engineers, the National Society of Professional

Engineers, and the new born Federation of Architects, Engineers, Chemists, and Technicians, have primary interest *only* in the "material interest" semicircle of activities. That this is true is indicated by the following clauses taken from the objectives of the following organizations:

American Association of Engineers: "The objects of the association *shall* be to promote the social and economic welfare of the engineer, to stimulate public service in the profession, to encourage and develop the efficiency of the engineer, and to promote unity in the profession."

National Society of Professional Engineers: "To advance and protect the economic and professional interests of the engineer, individually and collectively, through united effort, legislation, and public relations."

Federation of Architects, Engineers, Chemists, and Technicians: "The objective of the Federation is to improve the economic status of the technical, professional, and sub-professional employee in private industry, work relief, or unemployed."

An engineer knows that if half of the "circle of activities" is removed the semicircular section remaining is inherently mechanically unbalanced, both statically and dynamically. The same principle may be applied to an engineering organization. No organization which fails to balance psychic or technical interest with professional and material welfare can survive the test of time.

HOW THE MEDICAL AND LEGAL PROFESSIONS ARE ORGANIZED

This fact was discovered long ago by the American Medical Association and the American Bar Association. Both of these organizations give suitable attention to both the technical field and to the development of professional welfare.

The American Medical Association considers the technical features of the medical profession in its Scientific Assembly, while the political and professional questions are considered in the House of Delegates. The American Bar Association considers technical questions in both its Technical Sections and its Presidential Committees, while political and professional questions are considered in the General Council and the Technical Sections. In both of these successful, professional organizations professional interest is balanced with technical interest.

It may be of value to note that a member of a Bar Association is represented in a State Council and may be a member of one or more Technical Sections, while a member of the Medical Association is a member of the County Association and may be a member of one or more sections of the Scientific Assembly. The only difference between a "member" and a "fellow" is that the latter subscribes to the *Journal*. Each Technical Section is self-governing, in both the American Medical Association and the American Bar Association.

The fact that the American Medical Association with a membership of approximately ninety-nine thousand is a flourishing organization should be sufficient stimulus to the engineers of this nation to apply some of their organizing ability to their own profession and coordinate the aims and efforts of existing societies, rather than befog issues with additional officers, committees, and representatives in other new organizations.

COORDINATION OF EXISTING SOCIETIES, RATHER THAN NEW SOCIETIES, IS THE NEED

An unbiased engineer considering his societies will recognize two facts: (1) There are too many national engineering organizations, and (2) existing societies should be coordinated.

Before suggesting a plan of coordination for existing national societies it is well to consider what steps have been taken to date with this end in view. Fig. 3 shows simplified organization charts for the American Engineering Council and the Engineers' Council for Professional Development which represent in toto the efforts toward coordination at this time.

Such coordination as these two different groups represent should be supported to the utmost by all members of the profession. It would seem, however, that justified criticisms might be: (1) These organizations are not sufficiently representative (see Fig. 1); and (2) both the American Engineering Council and the Engineering Council for Professional Development should be branches of the same trunk.

It is with sincere earnestness that a proposed organization chart for a national and rational Engineering Society is presented in Fig. 4. This chart is sketchy because it is fully realized that the less appendages attached thereto, the less "dead-cats" can be hung thereon.

This chart is presented for the discussion and consideration of the engineering profession without comment. Each individual will have his own opinion as to representation, committees, technical sections, and other details.

The four types of membership, "fellow" (a licensed engineer who will be addressed as "Engineer Brown" similar to the custom in Europe and South America), "member" ("Mr. Brown"), "associate member," and "junior" are suggested because of the ease of coordination of memberships of existing societies.

Each technical section is self-governing with administrative officers as now exist who become representatives to a committee dealing with the proper interest.

All engineering-society publications pass through the Board of Editors. This in itself might prove of beneficial economic value because of possible reduced manufacturing costs which might be expected by the proper dispatching of each technical publication through a central plant, either owned or leased by the society to maintain a uniform load curve.

The question of dues is controversial to say the least, but it would seem reasonable to pay dues both to the state group and hence to the national organization, and likewise to as many of the technical sections as might be of interest to the individual.

It is not the purpose of this paper to specify the details of organization of a central, unified, national engineering society, but rather to demonstrate an existing chaotic condition in engineering organizations, to restate the basic engineering truth that certainly no more new organizations are needed, and finally, to instigate among the members of the profession a healthy wave of discussion concerning coordination of society activities.

Engineering Not a Caste

THE relation a profession bears to associated groups is especially pertinent to this matter of restriction. The profession of medicine is by law and tradition a caste; sharp, closed boundaries separate it from all other groups that touch on its functions. The profession of engineering is not a caste, but a vaguely bounded nucleus within a large body of technical workers. No wall separates them as a membrane divides the yolk from the white of an egg. The gradations of function are imperceptible. The professional nucleus continuously is drawing into itself much of the superior talent in the outer mass, on the one hand, and on the other continuously sending out men into almost purely executive functions. Close these free paths of interchange between professional, executive, commercial, and producing groups, and in my opinion, the engineering profession quickly will sterilize itself.—William E. Wickenden, *Electrical Engineering*, May, 1935, vol. 54, no. 5, page 472.

The FOUNDATIONS *of* MARXISM

A Review of Strachey's "Nature of Capitalist Crisis"

By HAROLD A. FREEMAN

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IT IS not surprising that high-ranking economic theorists—among them Böhm-Bawerk, Marshall, Edgeworth, Jevons, and Hayek—have had such little use for the contributions of Karl Marx and his followers. In fact, in the past 75 years, but few dispassionate students of economic science could find any semblance of logical correctness in the Marxian doctrine, nor any adequate criticism of their own doctrines in the writings of his supporters. For it is true that the idea of a proletarian society, conceived by Marx and Engels and enthusiastically supported by a multitude of earnest followers, has been advanced with only faint pretense of theoretical economic background. Marx's followers have either expounded socialism as thoroughly emotionalized propaganda, have established its validity upon the doubtful evidence offered by a materialistic interpretation of historical evolution, or have finally presented Marxism as philosophical truth arising out of the dialectic of their patron saint, the German philosopher, Hegel. No one of them, however, has attempted to do for Marxist economics what Adam Smith, Ricardo, Menger, and many others have done for capitalistic economics—a thorough investigation of the inner mechanics of the particular economic organization which each group maintains or implies is best adapted to the social progress of civilized nations. Nor have the Marxists ever successfully attacked capitalist economists on purely economic grounds after, for example, the manner of Böhm-Bawerk in his devastating theoretical criticism of the third volume of Marx's "Capital." These deficiencies are excusable on many grounds, but, in any case, it is little wonder that bourgeois economists have looked askance at an economic doctrine that reached its startling conclusions by means of analysis which was either non-economic, or economic with such an absence of rigorous logic that even their least competent associates could successfully attack it.

LONG-TIME AND SHORT-TIME CAPITALISTIC ECONOMICS—THE BASIS OF STRACHEY'S ATTACK

It is chiefly because of this that John Strachey's recent book[1] commands the attention of all apologists for capitalism, whether drawn from the ranks of professional economists or not. Mr. Strachey is an English Marxist, and is the author of that famous guide book for the modern proletarian movement—"The Coming Struggle for Power." In his previous writing Strachey stands out as one of the sanest of contemporary Marxists, but the contribution for which he deserves especial praise is his present work—the first adequate attempt to propound Marxism on the basis of a rigorous adverse economic analysis of contemporary theories of capitalist crises. To do justice to Strachey, many more pages than are at present available would be required. Accordingly, to avoid spreading the review thin, nothing will be said of Strachey's positive argument for Marxism, which occupies half the book; the present discussion will concern itself entirely with the critical analysis of crisis theory on which Strachey establishes his advocacy of Marx.

In his approach, Strachey strikes the theory of capitalism at its weakest point—its inability to explain crises with the same technique it employs to explain everything else. With the aid of the perfectly logical principle of final equilibrium, capitalist economists can fluently demonstrate any or all effects resulting from the operation of external or "long-time" forces—forces which have had sufficient time to "work themselves out." But in the short-time world in which we unfortunately have to live, these forces never work themselves out; they become mere tendencies, completely overshadowed in importance by the manifold short-time phenomena of the business cycle. Hence, as Strachey correctly points out in his discussion of the theory of equilibrium:

> Their science shows conclusively how capitalism adapts itself, smoothly, automatically, perfectly, to the ever changing pull and push of demand and supply; how it maximizes the "net satisfactions" obtainable by the whole population in a way impossible under any other system; how it uses all the factors of production, and uses them all the time..... Capitalist economic science establishes the impossibility of any interruptions of production, of any periods of dislocation or of waste—the impossibility, in a word, of crises.

THE CRISIS THEORY OF SOCIAL CREDIT

Since the capitalist economist proposes to explain crises not with his equilibrium technique but by special means, Strachey, using completely non-Marxist methodology, enters into an extended critique of these special theories. His first choice is a dubious one—the theory of "Social Credit"—best formulated by Major C. H. Douglas. It is likely that, even without the benefit of Strachey's analysis, Major Douglas' explanation of crises will be recorded in history merely as another example of confused thought; nevertheless, Mr. Strachey considers the matter carefully and well.

Major Douglas' explanation is grounded on the tragic paradox of starvation in the midst of plenty; hungry people watching foods dumped into the sea, underpaid laborers hired to burn wheat on the fields in order to force up its price, men without shirts while cotton is enthusiastically plowed under. How does this come about? The fault, as Major Douglas explains, is not in the productive end, for we already destroy part of what we produce. It must be consumption, for people obviously cannot buy all available goods at prevailing prices. But since these prices simply reflect costs of production (including profit) and since these costs of production constitute total private income, there should always be purchasing power in the hands of the people exactly sufficient in amount to clear all available markets of all goods. There should be no crises, slumps, or unemployment. But the point, according to the social-credit theorists, is that the entrepreneur's costs are divided into two great classes: (*a*) payments made to individuals in the forms of salaries, wages, dividends; and (*b*) all other payments, such as the costs of raw materials and bank loans. Consumer purchasing power over any commodity arises solely from the first flow of payments, whereas its price must be high enough to cover

[1] "Nature of Capitalist Crisis," by John Strachey. Covici-Friede, New York, 1935, $3.

Fourth of a series of reviews of current economics literature affecting engineering prepared by members of the Department of Economics, Massachusetts Institute of Technology, at the request and under the sponsorship of the Management Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

both classes of costs. Hence, the people will always have a deficiency of income in terms of prices; they will, unless subsidized by additional "social credit," never be able to buy all available goods.

Strachey shows up clearly Major Douglas' failure to distinguish between goods available for immediate consumption and those which are to be used in the further process of production, for therein lies the logical fallacy of social credit. Consumer income is actually derived from both capital goods and consumers' goods sources, whereas purchases for consumption purposes clear a relatively slight fraction of the total goods market. Thus, there is no necessity for identifying the total volume of costs (income) with the level of consumers' goods prices. Unless Major Douglas proposes to feed workers with steel ingots his extension of social credit will serve merely to emphasize the basic nature of the difference in the two types of goods, productive and immediately consumable, which any advanced economic society, whether capitalistic or not, is called upon to furnish.

THE THEORY OF OVER-SAVINGS

Strachey next deals with J. A. Hobson, who holds to the equilibrium theory of costs and prices, but asserts that deficiency of consumer income arises out of savings. Income would cover overall cost of production prices, says Hobson, if income receivers did not save a part of their receipts. But when they save, the unspent balance piles up on the one hand in the form of bank deposits and investments and on the other, as unsold goods which were produced by the efforts of the income receivers and should have been purchased by them with the payments received for those efforts. Hence, what is always needed is new money—additional purchasing power—equal in amount to that which has been saved; however, Hobson adds, such an inflationary credit policy can be limited simply by forcing down the volume of savings through redistribution of income along lines of greater equality, for it is well known that the percentage of income saved is much lower for those of average incomes than for those of high incomes.

To answer this widely held "over-savings" explanation of crises, Strachey develops the bourgeois economist's own arguments. If savings command a rate of interest, the return derived from entrepreneurical use of saved funds must exceed that rate. Such a return requires a differential between costs and selling prices and that differential arises out of improvements in producing and selling technique. Now it is admitted that the existence of savings has a depressive effect on price levels. Thus prices will fall, but costs must also decline if savings are to be profitably employed. But these costs are nothing more nor less than the incomes of consumers, which will accordingly also be lowered. Thus, if underconsumption prevailed at the outset as a result of savings, it will persist to the end.

THE THEORY OF DEFLATION

So far, Strachey has considered crisis theories requiring monetary inflation. But the classical capitalistic theory of revival is deflationary—it advocates liquidation and the reduction of costs to the dual ends of profit restoration and ultimate absorption of idle productive facilities. Strachey, therefore, brings his critique of crisis theories to a close with an attack on the most competent exponent of this program of deflation, Dr. Friedrich von Hayek, of the London School of Economics.

Hayek and his school believe that, far from saving too much, we save too little; that creditor interests, rather than ruining business by deflationary policies, ruin it by exercising exactly the policies that Hobson, Fisher, Keynes, and Douglas are advising them to exercise. The former claim that credit institutions *do* lend cheaply in depressions, either voluntarily or under governmental pressure, and if low private rates prove unsuccessful, the government is likely, for many good reasons, to enter the arena itself with one means or another of "distributing purchasing power." Furthermore, it is well established on theoretical and historical grounds that the resulting temporary inflationary prosperity with its attendant increasing spread between costs and prices, its overdevelopment of the capital-goods industries, and its cumulating discrepancies between prices of capital and consumers' goods inevitably ends in a disastrous situation for all interests concerned. Accordingly, Hayek and the deflationists assert that the only real solution of the crisis is to reduce the chief mobile cost elements—wages, taxes, and social services—thereby restoring the normal expansionary rate of profit which leads to an increased demand for labor and finally to increased purchasing power and prosperity. They advocate, in short, recovery by the paradoxical technique of immediate *reduction* of consumer purchasing power.

In more technical language, crises are held to be the result of expansionist monetary policy, which sets the consumer-goods and capital-goods industries competing for factors of production. Because of the inevitable passage of all inflationary money to the consumer-goods market this competition can be supported only by increasingly large advances of credit to the capital-goods industry. Whenever such credit advances come to an end the investment rate must decline to that of voluntary savings, the demand for capital goods collapses, and the crisis is imminent. It is, therefore, essential to maintain the equality of the rate on capital investment which reflects profit possibilities and the rate on savings out of which these capital funds arise.

INEVITABILITY OF CRISES UNDER CAPITALISM

Strachey establishes the basis for his defense of Marxism by observing that even Hayek would be forced to agree to the inevitability of crises under capitalism, for the factors most decisive for their control—the natural or equilibrium rates of investment and savings—are admittedly incapable of exact ascertainment. Furthermore, Strachey contends, the strict deflationary program, requiring as it does a steady equality in the rates of investment and savings, solves the problem of depression by holding the economic system in a permanent depression, for it is only a difference between the cost of the productive factors and the prospect for profit that leads enterprise to expand. Such a strict and severe credit policy is unlikely to be maintained; accordingly, if the condition of low investment rate is not feasible, the deflationist in his effort to hold the necessary equilibrium between savings and investment is forced to the remaining alternative of increasing the rate on savings. But such an increase is obtainable only by a redistribution of income from the poor to the rich, because of the greater capacity of the latter to save, which brings us to a conclusion exactly opposite that reached by the "over-savings" adherents. Thus, Strachey, by accepting the argument for deflation and carrying it forward, shows that it is a doctrine whose logical outcome is the ever-increasing benefit of the capitalist class, that is, that deflation is a depression remedy which restores and maintains an abnormal rate of profit at the ultimate expense of the remaining productive factor, labor.

Upon this critique of crises, of which this review has given but a bare outline, Strachey develops his argument for Marxism, building around a satisfactory restatement of the labor theory of value—the thesis that all the value goods possess is equivalent to the socially necessary labor embodied in their production. Strachey's analysis deserves, as do most things written by this leader of the theoretical Marxists, to be read in its entirety.

ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS

European Aeronautic Motors

THIS article is based mainly on the exhibits at the Paris Aircraft Show, November-December, 1934. From time to time comparison is made with the Paris Show of 1932. As to motor construction the following figures are given:

	Per cent in 1932	Per cent in 1934
Vertical in-line motors	3.3	0
Inverted motors	13.1	31.8
Double-row motors } Triple-row motors }	27.9	20.6 0
Radial motors	55.7	46.0
Double-piston motors (heavy oil)	0	1.6

From this it would appear that vertical in-line and W motors have practically disappeared. On the other hand, for low outputs the inverted in-line motors with air cooling have made considerable progress. For higher outputs the air-cooled radial motor has become a powerful competitor of the liquid-cooled in-line motor.

Whereas for years liquid cooling was preferred where high output per motor was desired there has been a notable change here lately. In the last years it would appear that the liquid-cooled motor has not gone beyond 800 hp, while the air-cooled radial motor has passed its former limit of 500 hp and is being manufactured in sizes as high as 1000 hp. Air-cooled in-line motors with outputs in excess of 600 hp have been tried experimentally.

As regards outputs the comparative figures are as follows:

	Paris, 1932, per cent	1934 per cent
50 hp and less	0	1.6
From 50 to 100 hp	8.2	7.9
From 100 to 150 hp	26.2	25.4
From 150 to 200 hp	6.6	11.1
From 200 to 300 hp	8.2	6.3
From 300 to 500 hp	8.2	7.9
From 500 to 1000 hp	32.8	28.6
From 1000 to 2000 hp	8.2	9.5
In excess of 2000 hp	1.6	1.6

Motors of 250 hp are used less commonly. It would appear that the greatest commercial field belongs to motors from 100 to 300 hp and from 500 to 1000 hp.

Liquid Cooling or Air Cooling? The author refers to liquid cooling as intermediary cooling, because after all both kinds of motors are cooled by air. Air cooling is already superior to water cooling today and is making progress as shown in the following table:

	1932 per cent	1934 per cent
Liquid cooling	27.9	23.8
Air cooling	72.1	76.2

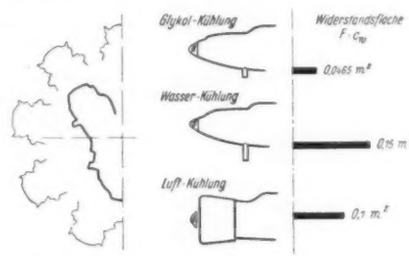
The reduction in power consumption in cooling, which means, in particular, losses due to resistance produced by the cooling surfaces, is attracting great attention. This subject has become of importance in view of the competition between air-cooled and liquid-cooled motors.

The amount of power lost through the resistance of cooling surfaces, hereinafter referred to as power lost in cooling, cannot as a rule be determined on the test bench, and is rather difficult to measure otherwise. It may reach, however, quite important proportions. It is therefore entirely improper to consider it as something as unavoidable as losses due to friction in the motor. However, these cooling losses have been considerably reduced as a result of research. In rough figures the following power losses due to cooling, expressed in percentages of useful motor outputs, have been found:

	Per cent
Radial motor, open	40
In-line motor, water-cooled	22
Radial motor with ring cowling	15
In-line motor, high-temperature cooling	8
Compressed-air cooling	6
Surface cooling	3

The simplest way to reduce the dimensions of the cooler (radiator) and its resistance seems to be by employing high-boiling-point cooling fluids, such as glycol. It was found, however, that this method constituted a source of danger to pistons, lubrication, and piston rings, and to the reliability of motor operation generally over long periods. It was therefore found advisable not to use the full range of temperatures possible with the liquid and to limit the temperature of the cooling liquid to 120 C. Comparatively frequent losses of glycol through leakage have led to abandonment for this particular use of assembled cylinder heads.

In England considerable attention has been devoted to evaporative cooling. Here again many difficulties appeared in the way of returning the condensed water. As a result, the most enthusiastic advocate of evaporative cooling, the Rolls-Royce Company, has recently gone back to water-cooling in horizontal flight and uses evaporative cooling only in take-off.



FIGS. 1 AND 2 COMPARISON OF AIR RESISTANCES OF IN-LINE MOTORS (LEFT) AND RADIAL MOTORS (RIGHT) SHOWING THAT AIR RESISTANCES CANNOT BE COMPARED EXCLUSIVELY ON THE BASIS OF FRONTAL AREAS, IT BEING IMPERATIVE TO INCLUDE THE COOLING PLANT AS PART OF THE ENTIRE AIRPLANE

[Notwithstanding its greater frontal area, Fig. 1, the radial motor may be superior to the in-line motor, Fig. 2. (F = frontal area; c_w = dimensionless coefficient of resistance; *Kühlung* = cooling; *Wasser* = water; *Luft* = air; *Widerstandsfläche* = area of resistance.)]

As regards the selection between the radial and the in-line motor, recent investigations on the subject of resistance of radiators have killed the argument which was used against the employment of radial motors for fast aircraft. Figs. 1 and 2 show a comparison between in-line and radial motors greatly favored by advocates of liquid cooling. The author has already expressed himself in opposition to the view that frontal projection of a motor provides a measure of the total resistance of the power plant in an airplane. Today there are numerical data on this subject and the following has been determined with respect to the resistance of water-cooled in-line and air-

cooled radial motors. Von Schlippe (*Luftfahrtforschung*, Vol. 11, 1935, No. 7, p. 192) says that as regards their total resistance including radiators, the two kinds of motors are about equal. The air-cooled power plant is decidedly superior for single-motor medium-size aircraft. In this case it does not seem possible to reduce the water-cooled motor with its radiator to the same low resistance which is attained by the modern cowled air-cooled motors.

Such a reversal of opinion is expected to be of the greatest importance for development of aircraft. The liquid-cooled in-line motor, if it is not forced into a difficult location for reasons of resistance and weight, will have to pass in general to high-temperature cooling, in which case the temperatures of the paths swept by the piston will have to approach those of the air-cooled motor.

In general, in practical flying circles a watchful attitude is maintained toward the employment of glycol and also toward evaporative cooling. In the experimental models of the French Dewoitine D 500 plane equipped with a 700-hp Hispano engine, high-temperature cooling was suggested and rejected, water-cooling being used instead. In the United States high-temperature cooling was tried in the Curtis A 8, but here again it was given up in so far as the standard type was concerned and the original Conqueror motor replaced by an air-cooled radial type.

The air-cooled motor does not present the final solution of the problem. Its cooling surfaces (cylinders) must be directly exposed to the flow of air and therefore create additional resistances.

The author enumerates various methods by which the power losses due to resistances connected with air cooling of the motor can be reduced, naming such devices as the Townend ring and compressed-air cooling.

The author briefly mentions the matters of fuel and lubrication, Diesel engines, and variable-pitch propellers. (Dr. of Engrg. M. Gosslau, *Zeitschrift des Vereines deutscher Ingenieure*, vol. 79, no. 19, May 11, 1935, pp. 569–578, 41 figs.)

INTERNAL-COMBUSTION ENGINEERING

Combustion in an Internal-Combustion Engine

AN investigation of the combustion of standard and safety gasolines and Diesel fuels was made in the combustion apparatus of the National Advisory Committee for Aeronautics under conditions of temperature that permitted ignition by spark with direct fuel injection in spite of the compression ratio of 12.7 employed. The influence of such variables as injection advance angle, jacket temperature, engine speed, and spark position was studied.

The most pronounced result was that an increase in the injection advance angle (beyond a certain minimum value) caused a decrease in the extent and the rate of combustion. In almost all cases combustion improved with increased temperature. For an increase in engine speed, the rate of pressure rise increased and the time interval in seconds between injection and the spark necessary to effect ignition was considerably shortened. Although all three fuels reacted in the same manner to these variable conditions, the reactions differed decidedly in extent. The results show that at low air temperatures the rates of combustion vary with the volatility of the fuel, but that at high temperatures this relationship does not exist and the rates depend to a greater extent on the chemical nature of the fuel.

In tests with ordinary gasoline it was found that for a given injection advance angle combustion improved with rising temperature, but it was only for the earlier injection advance angles that the effect was considerable. At 1550 rpm a difference of 10 deg in the injection advance angle usually had a slightly greater effect than a 50 F change in jacket temperature. It was thought that the failure to fire with very early injection might be due to the fuel penetrating to the bottom of the combustion chamber before the occurrence of the igniting spark, which would leave little fuel in the top of the chamber near the spark plug. The spark plug was so constructed that the gap was about $^1/_{16}$ in. from the piston crown position at top center. It was found that the burning was efficient, but in some cases slightly slower than with the spark in the center of the chamber. In general, it was found that although the distribution of the fuel is a factor in controlling whether or not the spark ignites the mixture, it is not the only factor. Until further work has been done therefore the possibility that chemical change in the fuel is a determining factor should not be forgotten.

In general, it would appear that the characteristics of the combustion of a liquid fuel are determined primarily by its history from the time of injection up to the instant of ignition. Apart from the mode of injection, the factors controlling the course of the combustion therefore are: (1) The time interval between injection into the combustion chamber and the ignition, (2) the temperature and pressure of the air and fuel mixture during this interval. If the mixture of the fuel and air is heterogenous, the shorter the time interval (above a certain minimum) the better the combustion. As the temperature of the air is increased this effect of time is decreased. (A. M. Rothrock and Mildred Cohn, National Advisory Committee for Aeronautics, 1934, Report No. 512, 17 pp., 17 figs.)

The Wibu Method of Supercharging

THIS process has been developed by two Polish engineers, Adam Wicinski and Jakob Bujak, and depends upon the use of the mass inertia of the air column in corresponding suction pipes. It differs from previously known methods in which the resonant oscillations of the air column are utilized.

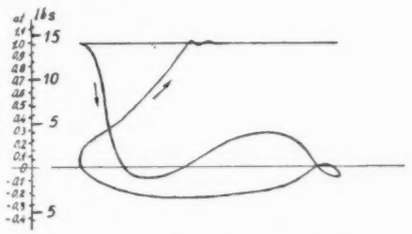


FIG. 3 PRESSURE CURVE IN THE CYLINDER DURING EXHAUST AND SUCTION STROKES

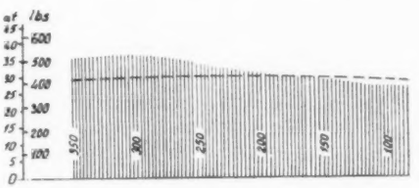


FIG. 4 COMPRESSION PRESSURE AT VARIOUS REVOLUTION SPEEDS

The operation of the Wibu system is as follows: In the first portion of the suction stroke, the suction valve is slightly opened, and as a result a partial vacuum of about 0.3 atm is created. At about the middle of the suction stroke the suction valve is fully opened, and the vacuum causes a high air velocity up to 200 m per sec.

Under these conditions the air column in the suction pipe shows a much greater increase in kinetic energy than with a resonant oscillation.

Experiments were made on a single-cylinder Diesel engine with a cylinder diameter of 300 mm, the piston stroke being 450 mm and the speed 300 rpm. An increase in power from 60 bhp to 75

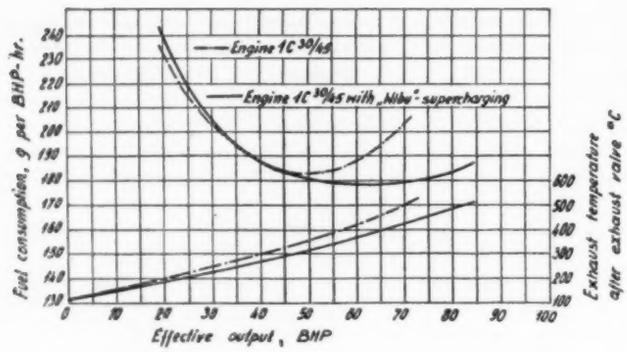

Engine 1C 30/45
Engine 1C 30/45 with „Wibu"-supercharging
Fuel consumption, g per BHP-hr.
Exhaust temperature after exhaust valve °C
Effective output, BHP

FIG. 5 FUEL CONSUMPTION AND EXHAUST-GAS TEMPERATURE WITH AND WITHOUT SUPERCHARGING

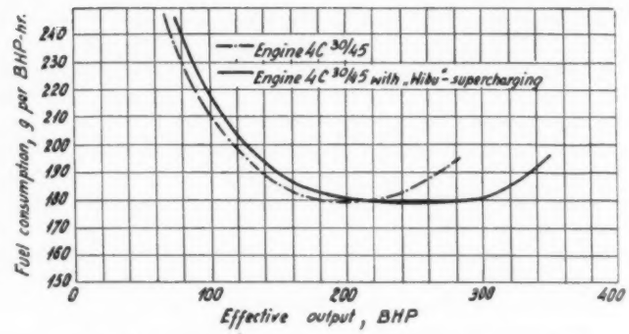


FIG. 6 POWER AND FUEL CONSUMPTION WITH AND WITHOUT PRESSURE CHARGING

bhp was obtained and the mean pressure was increased from 5.65 to 7.1 kg per sq cm. Fig. 3 shows the variation in pressure in the cylinder and it is seen that the compression begins at 0.18 atm. Fig. 4 shows the compression pressure at varying speeds of revolution. The dash line indicates the pressure without supercharging, and at normal load. Fig. 5 shows fuel consumption and exhaust-gas temperature with and without supercharging. Fig. 6 shows the corresponding power, fuel consumption, and exhaust-gas temperature for the single-cylinder motor at 300 rpm with and without Wibu pressure charging.

Several engines were equipped with Wibu supercharging system and it is claimed that in one installation with a four-cylinder motor, an increase from 240 to 300 bhp was obtained and the mean effective pressure rose from 5.65 to 7.1 kg per sq cm.

It is said that in comparison with other supercharging systems the cost of conversion of existing engines is small. All that has been done is to change the inlet-valve cams and the construction of corresponding suction pipes, the dimensions of which are determined from an empirical formula. It is claimed that the Wibu system can be used in combination with an exhaust-gas turbine and turbo blower. The blower improves the working of the Wibu supercharging system and the power and efficiency of the exhaust-gas turbine are raised on account of the increase of exhaust-gas content and consequently the higher air pressure developed in the turbo compressor. (Prof. Ludwig Eberman in *The British Motorship*, vol. 16, no. 182, April, 1935, pp. 28–29, 8 figs.)

Small Four-Cycle Diesel Engines With Turbulence Chamber

TURBULENCE-chamber engines on the Oberhänsli principle are built by the Vomag-Betriebs-A. G. In this engine the fuel pump, shortly before top dead center, sprays fuel through a nozzle into a glowing uncooled cup at a pressure of about 85 atm (1200 lb per sq in.). By the coaction of the red-hot cup and the heated air, the atomized fuel is evaporated and burned. The compression pressure is about 25 atm (350 lb per sq in.), and the compression ratio about 14:1, while the combustion pressure varies between 45 and 50 atm (650 and 700 lb per sq in.). A heating coil serves for starting the engine from the cold state. In the way of examples of Vomag engines, a four-cylinder, 4.4 by 6.30 in. automotive model, of an output of 78

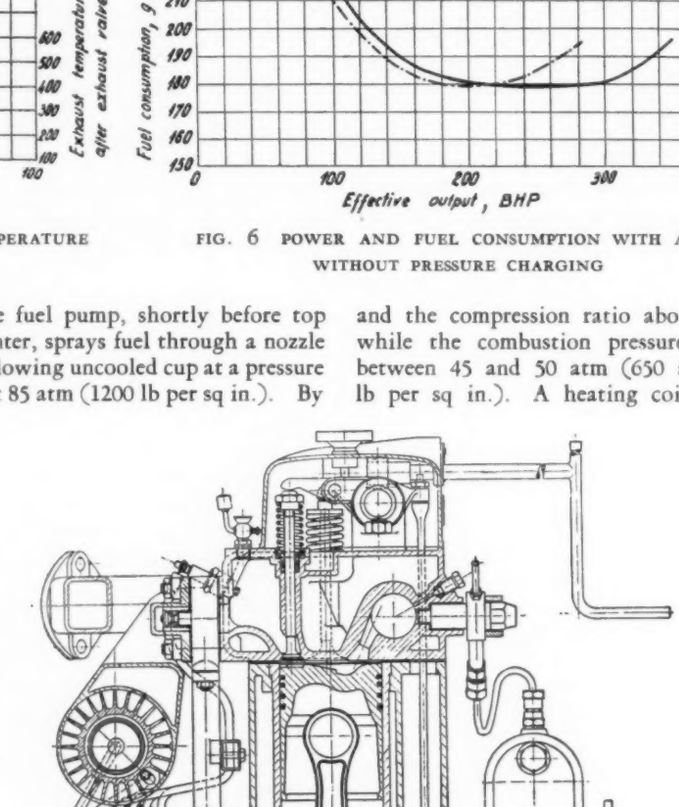


FIG. 7 SECTION THROUGH KAMPER ENGINE WITH TURBULENCE CHAMBER

hp at 2000 rpm, and a two-cylinder model of 41 hp at 1500 rpm may be mentioned.

The Hansa-Lloyd and Goliath-Werke, of Bremen, also build Oberhänsli engines and equip their trucks with them. A typical engine of their make is a four-cylinder, 3.4 by 5.6 in. model developing 50 hp at 2400 rpm.

The firm of Heinrich Kämper Motorenfabrik A. G. has developed a turbulence-chamber process of its own. The turbulence or "turn-over" chamber is seen on the right of the cylinder cover in Fig. 7. It is a flat cylindrical cavity whose axial length is about one-third of its diameter. During the compression stroke, the air enters tangentially from below and thereby is set revolving. The fuel is introduced radially into this air whirl from the horizontal injection nozzle and is deflected in the sense of rotation of the air. In this process, the jet is rendered more compact at the top and spread out below, and combustion sets in at the lower end of the chamber. Combustion in the turn-over chamber is incomplete, and the larger proportion of the fuel is both chemically and thermally prepared by this partial combustion. The main phase of the combustion process occurs in the cylinder after the piston has started to descend.

The compression ratio in the Kämper engines is between 16:1 and 18.5:1, while the compression pressure is about 40 atm (570 lb per sq in.) and the maximum combustion pressure 48.5 atm (680 lb per sq in.). Owing to the high compression, the air temperatures in the turn-over chamber are correspondingly high, and the fuel is sufficiently heated in the large turbulence chamber. For this reason, cooling of the chamber has been retained. Bosch injection pumps and nozzles are used. The injection pressure is between 70 and 80 atm (1000 and 1150 lb per sq in.) and the duration of injection 28 to 30 deg of the crankshaft motion.

A typical engine of this make is a four-cylinder, 4 by 5.7 in. automotive model developing 40 to 60 hp at 1250 to 2000 rpm. Starting is facilitated by heating coils incorporated in the turn-over chambers. For cases where the power starter is not needed, the firm has designed a gasoline hand-starting device with an auxiliary carbureter, which is used in conjunction with an additional combustion space. Kämper engines are in use for driving trucks, trailers, locomotives, cranes, dredgers, boats, compressors, dynamos, and pumps and for similar purposes.

Another type of turn-over chamber is employed by Jaehne, Landsberg/Warthe, on their horizontal small four-cycle Diesel engines. The combustion air is led past the injection nozzle during injection. The smallest single-cylinder engines of this type develop 9 to 10 hp at 900 rpm. (Dr. W. Lind in *Engineering Progress*, vol. 16, no. 3, March, 1935, pp. 62–70, 19 figs.)

LUBRICATION

Lubrication Research

SOME of the difficulties of deducing the properties of a lubricating oil from tests on a bulk sample of the oil are brought out in a technical paper issued by the Department of Scientific and Industrial Research (Great Britain), entitled "A Study of the Boundary Lubricating Value of Mineral Oils of Different Origin." The report deals with the conditions such as exist just before the seizing of moving parts takes place, when the film of lubricating oil between two smooth bearing surfaces is so thin that the molecules on the outermost layer of one surface are within the range of the cohesive forces due to the outermost molecules on the other surface. Such conditions, which are known as boundary conditions, become important when starting or stopping the engine. When they are present, the friction, it is stated, may be as much as 100 times as great as when the surfaces are separated by a fairly thick film of oil.

The report points out that there is much experimental evidence to show that a solid surface can produce considerable modifications in the properties of a layer of liquid in contact with it. For instance, it can selectively pick out certain constituents from a mixture such as an oil and concentrate them in the surface layer. Hence, the properties of this layer—for example, the effect of heat upon it—may be quite different from the properties of the oil in bulk. Although in the course of preparation the oils used in the experiments have been distilled at high temperatures and were thus presumably in a state of chemical equilibrium, yet experiments described in the report show that a rise in temperature of the oil of, say, 18 to 30 C, when it occurs in the presence of an adsorbing surface, may be accompanied by a considerable amount of chemical activity in the boundary layer. Such properties of the layer cannot be predicted from a knowledge of the behavior of the oil in bulk, but it is just these properties which become all-important when, owing to the thinning of the oil film which precedes seizure of the bearing surfaces, boundary conditions arise.

Another point revealed by the investigations described is that of the rôle of wax in mineral oils. It is shown that wax, the presence of which in an oil is generally regarded as detrimental, as far as fluid lubrication is concerned, may in certain cases exert a beneficial effect when boundary conditions arise.

In most of the work described the bearing surfaces themselves were of steel, but a few experiments were carried out in which silver-alloy surfaces were used. In these cases it is shown that the attractive forces are more intense than with steel surfaces and that this fact may influence the constitution and properties of the layer of oil in contact with the surfaces. (*The Steam Engineer*, vol. 4, no. 8, May, 1935, pp. 315–316)

MACHINE-SHOP PRACTICE

The Reconditioning of Defective Metal Parts

METHODS of repairing cracks and other defects in various components of machines and of reconditioning worn engine parts have recently been introduced in Germany under the names of the Gussolit welding process and the Schliha metal-spraying process.

The Gussolit process is credited to Dr. Klopstock, who has developed a material described as a high-grade cast-iron alloy, which, it is understood, has an extremely fine structure and possesses a Brinell hardness of 230. Few data of a technical nature regarding the process are available for publication, but it is said that the part to be treated is heated to a temperature of from 850 to 900 C, coated with a special flux, and Gussolit welding rod, which is supplied in the form of square bars, melted into the crack or defect. During the melting of the welding rod, it is stated, the flame employed is made to play in a direction parallel to the surface of the work in order to prevent excessive heating of the metal. Great stress, however, is laid to the fact that, owing to the moderately high temperatures employed, there is no distortion of the piece as a whole.

It is stated that cracked motor-car cylinder castings, turbine casings, and other engine parts have been successfully repaired in this way, the Gussolit alloy penetrating deeply into the cavities and making a strong and sound joint. Defects in machine-tool components have also been made good by the use of the new process. One such instance

has been brought to notice; after the final grinding operation, three blowholes were revealed on the working face of the arm of a radial drilling machine. These were filled with Gussolit, and after regrinding, the arm, it is said, presented a uniform and smooth surface free from blemishes. The coating of porous high-pressure steam and hydraulic-press cylinders, with a thin layer of Gussolit, has enabled them to withstand pressures of 130 atm, whereas previously leakage had occurred, owing to porosity, at pressures of 25 atm. Again, parts previously rejected owing to faults of workmanship, such as holes having been drilled too large, it is understood, have been successfully reclaimed by the application of thin layers of Gussolit.

The Schliha metal-spraying process is used mainly for the building up and reconditioning of worn engine parts, such as internal-combustion-engine cylinders, shafts, and bearings. A special spray pistol is employed, and the metal to be sprayed, which may be steel, bronze, copper, or aluminum, is fed automatically in the form of wire to the nozzle where it is melted by an oxy-acetylene or oxyhydrogen flame and projected as a fine spray by means of compressed air at a pressure of 2.5 atm, the compressed air, incidentally, also having the effect of cooling the nozzle.

While the data communicated are somewhat meager, a good deal of work appears to have been carried out in the spraying of steel, and it is claimed that a layer of steel of any desired thickness may be sprayed on to a worn surface and that the coating is very firmly adherent and can be subsequently ground to size. Steel sprayed on the surface of worn engine cylinders is stated to have a Brinell hardness of 300. As already indicated, the thickness of the sprayed layer may be controlled at will, but it is pointed out that this should not normally be less than 1 mm.

The procedure adopted is that shafts and similar components are rotated in a lathe and the worn parts built up by allowing the spraying pistol to rest on the headstock of the lathe. For the internal spraying of hollow objects, nozzles bent at an angle are used, the piece being rotated in a lathe as before. For the spraying of worn internal-combustion-engine cylinders, however, an automatic machine has been designed, in which the spraying nozzle, and not the work, rotates. The rotating nozzle is driven by a small electric motor, so that the entire surface of the cylinder bore is capable of being given an evenly sprayed coating. Excess steel particles are removed by suction, the cylinder casting standing over a hole in the base plate of the machine; the suction, it is stated, also has the effect of cooling the cylinder.

It is claimed that by the use of the machine a cylinder 2.95 in. in diameter and 5.79 in. long can be given a sprayed coating 1 mm thick in 25 min. For dealing with multi-cylinder engines, machines equipped with up to 12 automatic rotating spraying pistols, it is understood, are being employed. It is stated that an engine having 12 cylinders of the dimensions quoted can be sprayed to a depth of 1 mm in 25 min. Another interesting application of the new process is that of spraying the piston-ring slots with steel as a precaution against premature wear, and it is stated that a firm of aircraft-engine manufacturers is adopting this procedure. (*Engineering*, vol. 139, no. 3614, April 19, 1935, p. 415)

Recent Developments in Worm-Gear Manufacture

THE original is an extensive paper and space is lacking for its complete abstract. The author asserts that the greatest change that has taken place within recent years in connection with worm gearing is the adoption of high lead angles and close ratios. Whereas formerly worm gears were used out of necessity, because other types of gear reduction could not give large ratios in a compact space, nowadays worm gears are also used from choice on close ratios because they have new advantages over other types of gear drive.

The paper shows how by utilizing certain recent developments in worm-gear manufacture a combination of old and new processes can be obtained which forms a sound basis for the manufacture of accurate worm gears. The author starts with worm-thread grinding. It is essential in a worm-thread grinder that some arrangements be available whereby the operator can true the grinding wheel and set the machine to produce accurately the required shape of thread, and also reproduce this thread shape easily on any future occasion. In the past the accuracy of the profile shape has been dependent to a great extent on the skill of the operator, but the most recent developments in this art have overcome this difficulty and it is now possible to insure accuracy of profile shape in conjunction with convenience of operation. Formerly the disk-wheel method of worm grinding was used. Nowadays the disk type of wheel has been eliminated, and the modern grinding wheel is of large diameter and annular form, grinding on the outside periphery which is in contact with one side of the worm thread. The advantages of the annular wheel are set forth in the original article. One of these advantages is that with an annular type of wheel no after-polishing is necessary.

The hob is discussed next, the author saying that the biggest source of inaccuracy in worm-wheel hobbing lies in the probable inaccuracies of the hob, with some of these inaccuracies resulting from the reduced hob diameter. Among methods of improving the accuracy of hobbing are mentioned the use of a hob initially larger in effective diameter than the worm, as well as the improved radially relieved hob. This leads the author to the discussion of the built-up hob, the A.E.C. hob, and an alternative method used by the author in which the normal gashing of the hob is retained and the teeth at the leading end of the hob are made progressively thinner than those at the trailing end. This is done by cutting the two sides of the hob teeth at different leads to the lead of the worm. If one side of the hob thread is cut and relieved at a longer lead and the other side at a shorter lead than that of the worm, it becomes possible to make the hob teeth vary in thickness from a thin tooth at the leading end to a thick tooth at the trailing end. The hob can then be ground at the true lead of the worm and this will give the effect of a varying land on the teeth, the land having a maximum width at the trailing end and disappearing part way along the hob. The advantage of this arrangement is that it gives the same results as the A.E.C. hob, and in addition the hob may be gashed in the ordinary manner at right angles to the thread. Consequently the hob teeth are of constant length and the life of the hob is not limited by short teeth at the leading end.

The hob must be profile ground after hardening to insure accuracy and silence of operation. The author mentions here the factors connected with the use of a pencil wheel and also the double-row hob.

In discussing thread shape the author refers to his own design of thread form tested at the National Physical Laboratory and also considers the effect of thread shape on methods of manufacture and the advantages of the straight wheel profile.

Considering worm-gear manufacture as a whole, it will be apparent that the processes described help to overcome the difficulties which previously existed in worm-gear production. The thread shape which has been suggested lends

itself to accurate production in thread grinding by the new process, and at the same time it possesses in itself the mathematical features desirable for giving high efficiency and heavy load capacity. The new thread-grinding process eliminates the old trial and error methods of obtaining the thread shape, and does not leave everything to the skill of the operator. In addition to this, it has the advantage of increased output and better thread finish. The thread-grinding machine lends itself to the profile grinding of the new types of hob, the combination of the grinding machine and the hob insuring that the hob is always an exact replica of the worm. The hob itself is not affected by the resharpening, and thus is eliminated one important source of inaccuracy with the older types of hob, so that worm-wheel manufacture is placed on a sounder basis.

With the old methods it was impossible to proceed beyond a certain degree of accuracy because of haphazard methods and fundamental theoretical inaccuracies which could not be eliminated. However, once a sound basis founded on theoretically accurate methods has been developed, it is possible to concentrate on improving the accuracy of machines and tools, and there is no limit to the accuracy which may be ultimately attained. (*The Journal of the Institution of Production Engineers*, vol. 14, no. 2, February, 1935, pp. 72–90, for the original paper, 12 figs., pp. 91–102 for the first instalment of the discussion)

MARINE ENGINEERING

Wagner-Bauer Boiler

THIS is a water-tube boiler with drums. No further details of design are given.

In water-tube boilers installed in two fast Customs cruisers the heat-transmission surfaces are, as follows:

Heating surface (water-wetted), sq m	10
Portion thereof of the radiation heating surface, per cent	6.3
Superheating surface, sq m	13
Air-preheating surface, sq m	80
Evaporation, kg per hr	4000
Steam pressure, atm	50
Steam temperature behind superheater, F	480

(Part of a paper by O. Jebens, presented to the Institute of Marine Engineers in a Symposium on High-Pressure Boilers, abstracted through *The Steam Engineer*, vol. 4, no. 7, April, 1935, pp. 271–273 and 312)

Steamships With Main Boilers on Deck

FROM time to time various methods have been employed to increase the cubic capacity of cargo steamers, because many kinds of cargo need space rather than deadweight carrying capacity. Considering the steam machinery for a ship, it is seen at once that the engine or turbine must be located at the bottom of the ship, except where electric transmission to the propeller shaft is used, but the boilers may be lifted on deck. The stability of the ship in loaded condition as a rule will be unaltered or somewhat greater, because the cargo filling the space where the boilers were will usually weigh more than the latter. In ballast condition, however, there is a change. With boilers on tank top

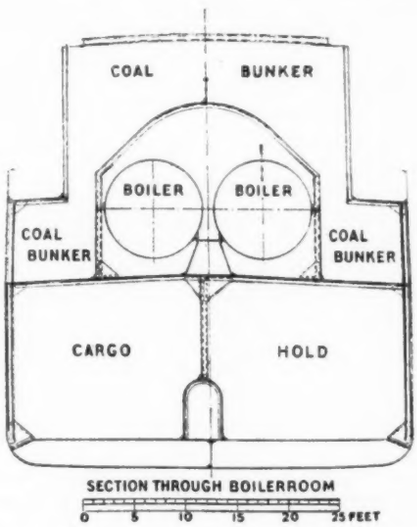


FIG. 8 CROSS-SECTION OF STEAMSHIP WITH MAIN BOILERS ON DECK

as hitherto, the stability is too great, causing violent rolling of the ship. With elevated boilers the rolling motion becomes easier for two reasons:

(1) The excessive metacentric height which most cargo ships have in ballast conditions is considerably reduced.

(2) The moment of gyration of the ballasted ship is augmented, because the masses of the bunkers, boilers, etc., are placed further away from the axis of rolling.

The axis of roll is also lifted somewhat higher above the ballast weights, whereby the moment of gyration is further increased. Actual experience shows that, for instance, the period of roll is augmented, in one case, from about 8 sec for a complete roll to about 11 sec. The beam of the ship may now be increased somewhat and still no unpleasant rolling sets in; and thereby the ship gets a marked increase of carrying power at shallower draughts, which is of considerable value when the ship has to go through lock gates and over river bars.

Having the boilers on deck improves the working conditions for the stokers. The ash hoist becomes unnecessary, as the ashes can be passed overboard through a chute. The accommodations for the officers are improved by being collected into one house which is compact and easy to light and ventilate. There is no heat from boiler uptakes and no damage to cargo by heat either in hold or in spare bunker. The gain in cubic capacity for a given deadweight is found to be from 6 to 10 per cent, the latter figure referring to fruit carriers. The gain in capacity must be judged in comparison with the percentage of capacity which brings the earnings, hence in many cases the dividends may be multiplied by this increase in capacity. No increase of steel and other weights is caused, and the cost of construction is probably reduced. It has been found best to support the boilers on longitudinal girders and bulkheads resting in their turn on bulkheads below and suspended from bulkheads above the boiler deck. By this means the space below the boiler room becomes quite unobstructed.

The rolling motion causes no serious wash inside the boilers as proved by model experiments as well as by the fact that the superheat temperature of the steam does not fall during heavy rolling motion, which it would do if the superheat had to deal with water carried along by the steam.

The register tonnage per cubic foot of cargo capacity is only slightly smaller than before, as might be expected, the advantage amounting to about 1 to 2 per cent. Usually, when the engine space below the tonnage deck does not amount to 13 per cent of the gross tonnage, part of the engine and boiler trunks above this deck is registered and added so that the 32 per cent reduction is secured. A pure deadweight carrier with elevated boilers will therefore be at some disadvantage in this respect. The type has proved perfectly seaworthy in the severest weather, and the boilers and engines have worked normally.

Boiler installations in accordance with those just described have been made on several vessels. The discussers were mainly in agreement with the ideas of the author. In the discussion the author added that the steamboat *Felix-Henri* had crossed the Bay of Biscay

32 times and had kept to service at times when some of the big liners had been obliged to heave to. Even during the first year when she was comparatively lightly loaded the rolling had not been reported to be more than 18 deg either way. On the question of the necessary draft the author stated that in one case in which the coal was not first class, the funnel had not enough draft and another 5 ft were added to its height. (K. G. Meldahl, paper before the Institution of Naval Architects, abstracted through *The Engineer*, vol. 159, no. 4137, Apr. 26, 1935, pp. 431–432, 1 fig.)

MEASURING INSTRUMENT

A Turbulence Indicator Utilizing Diffusion of Heat

IN cooperation with the National Advisory Committee for Aeronautics, the National Bureau of Standards for several years has been studying methods of determining the turbulence in wind tunnels, especially by the "hot-wire" method and the sphere method. This paper describes a third method.

The effect of turbulence upon the diffusion of heat from a small electrically heated wire in an air stream was investigated. The turbulence of the stream was introduced by a series of geometrically similar screens placed one at a time across the upstream section of the tunnel. With the wire set at various distances from the screens, curves of temperature distribution were obtained by traversing the heated wake at a distance of 2 in. behind the wire with a small thermocouple. A single relation was found to exist between the width of the wake at half maximum and distance in screen wire diameters from the several screens. The correlation of width at half maximum with percentage turbulence, as measured by the hot-wire method, could be represented approximately by a single curve. (G. B. Schubauer, National Advisory Committee for Aeronautics, 1935, Report No. 524, pp. 1–5, 5 figs.)

MOTOR-CAR ENGINEERING

Air Resistance and the Automobile

EXTENSIVE tests on the air resistance of automobiles of various shapes have been carried out in France. The tests were carried out in a rectangular wind tunnel at velocities varying from 6 to 30 m per sec. The formula for air resistance is $R_x = C_x S V^2/16$.

From the results of these tests the values of C_x have been determined by calculation, adopting an average efficiency of axles and tires of 0.95. The calculated values and experimental values seem to have come pretty close to each other. It was found that the mere change of contour of the coach work within certain specified limits only contributes an improvement in the coefficient of resistance of 5 per cent and an improvement in the speed of 1.6 per cent, which appears to be altogether negligible.

Tests were next made with various types of wings and it was found that by dispensing with the wings, which does not appreciably reduce the maximum suction, a considerable drop in the coefficient is brought about, and that the reduction in resistance thus obtained is about seven times as great as that produced by modifying the profile. It would therefore appear that there is great promise in work on mud guards and running boards.

A gain of 11 per cent was found by cutting out the headlights in their present form and a trial on the track with faired lights and without lights brought an increase in speed of 5 km per hr. The speeds rose from 137 to 160 km per hr for a Maybach pattern profile on removing headlights, running boards, and wings, and fairing the bottom of the vehicle.

The author illustrates the applications of his theory by a reference to a carnivorous insect found in the Landes and called Cocktail Beetle. It can run fast and when it runs it raises itself a fair amount on its legs, which are rather long, and bends its body in a profile which is concave toward the top with its head lower than its abdomen. In brief, like an aircraft wing inverted.

The flow of air around a vehicle is diagrammatically illustrated and analyzed. The conclusion to which the author comes is that under the present circumstances, it is a question whether it is really proper for the modification in the shape of coach work to lay claim to aerodynamic considerations or whether they should not simply be put under commercial headings. (The first part of a paper by M. Andreau. Original published in the Journal of the French Society of Automobile Engineers and abstracted through *The Automobile Engineer*, vol. 25, no. 329, February, 1935, pp. 75–77, 7 figs.)

Progress of the High-Speed Diesel Engine in Road Transport

THIS extensive paper deals primarily with British conditions. There the four-stroke airless-injection high-speed Diesel engine has proved to be an enormous success as power unit for road transport vehicles.

An estimate arrived at from all the most reliable sources of the number of Diesel engines now on the road in Great Britain shows that there are between 10,000 and 11,000 of them. Approximately one-half of these are of the direct injection type and the remainder equipped with various designs of pre-chamber head. From this point of view an interesting collection of 24 different designs of combustion head, some of them now defunct, is shown in Fig. 6 of the report, not reproduced here. The largest manufacturers in England are Gardner with 3000 engines, Layland with about 2000, and A. E. Co. with about 1900.

The largest engine available for road-transport vehicles in Great Britain is the Mercedes-Benz six-cylinder engine developing 120 bhp at its maximum speed of 1600 rpm, and the smallest engine is the Perkins four-cylinder developing 42 bhp at 3000 rpm. This shows that Great Britain now has a very complete range of sizes of engine available. Data as to European conditions are briefly given in the original paper.

The author discusses in detail the direct injection vs. pre-chamber. The disadvantages of the latter are a complicated and expensive cylinder head with its added weight and liability to heat distortion and cracking; heat losses amounting to 15 per cent resulting in reduced power output and economy; higher compression ratios resulting in increased maximum pressure and the need for heavier parts; increased lubricating-oil consumption; and often incomplete scavenging of the chamber.

The pre-chamber or "two-cell" engine is in fact, "an easy way out of a difficult job," the difficulty being the designing of a smokeless, efficient, reliable, and smooth engine, fit to be used on the highways as the power unit for all types of vehicle. It is claimed that a two-cell engine only requires a comparatively low injection pressure, say, 1000 lb per sq in., and that the sprayer nozzles can be made with one single orifice of fairly large diameter. If these can be claimed as advantages, they are, in the opinion of the author, insignificant and of no importance. There are thousands of one-cell engines now working with injection pressures of about 2000 to 2300 lb per sq in. and sprayers with three or four orifices of only 0.01 in. diameter, which are entirely satisfactory and trouble free. There is ample evidence today that the maintenance and renewal costs of a two-

cell engine are very considerably higher than those of the one-cell design—in some cases as much as 200 per cent higher. The author believes that the final verdict will be in favor of the open-chamber engine. On the other hand, however, in Germany over 95 per cent are two-cell engines.

Heat distortion is proving to be a most serious matter with certain pre-chamber engines. There is an engine now running which has required no less than six new cylinder heads in less than two years' service.

Maintenance costs and selection of engines are discussed in considerable detail. Experience has shown that for a well-designed engine one may expect the cylinder wear to be 0.001 in. for every 4000 to 5000 miles run, and that big ends may be expected to last for 80,000 to 100,000 miles in an omnibus and considerably more in a long-distance goods vehicle, as is also the case with main bearings. These results are generally better than those obtained by gasoline engines. In August last, a lorry engine belonging to a Sheffield firm was sent in for overhaul for the first time, after having run over 128,000 miles without failure of any sort. The total cost of repairs and spares was 35s for a period of two years and one month. The engine was twice decarbonized. Cost of overhaul was £54 which equals 0.101d per mile.

The haulage contractor can economize from 70 to 80 per cent of his fuel bill by employing Diesel engines instead of gasoline, in addition to which time is saved in refueling vehicles. On the other hand, Diesel-engine vehicles in England have to pay a higher road tax than gasoline vehicles, but the extra tax charged for a Diesel engine is really small when compared with the economy which can be effected in the fuel bill. This matter of economy is presented in the original article in the form of a running analysis and a table. The large majority of these engines develop their highest torque and brake mean effective pressure as well as best fuel consumption at between 1000 and 1200 rpm. This speed is also best for a smokeless exhaust in most engines. The ideal arrangement would be to provide a five-speed gear box, the fifth speed being an over-drive.

As regards crankshafts, gasoline-engine makers are now producing Diesel engines which are interchangeable with gasoline engines, thus simplifying the work of conversion of a vehicle to Diesel power by economizing the costs of fitting, but in doing this they are obliged to keep the crankshafts to exactly the same length as that of the gasoline engine. If the gasoline-engine shaft was designed with a normal margin for safety, the Diesel shaft of the same length must have either little or no margin for safety or even be in danger of failure sooner or later.

The great demand for these engines has brought about a new phase in motor work, i.e., that of converting existing gasoline vehicles to Diesel power. This has given employment to a great number of men and is most interesting work. It requires a considerable knowledge of the manufacture of motor vehicles and a considerable skill in designing and fitting. The enormous number of different types of chassis calls for ingenuity and a lot of patience. Chassis have to be lengthened in many cases, and the fitting of the clutches and the suspension are sometimes difficult and costly. Recently a six-wheeled steam lorry was converted to Diesel power. The work was almost impossible to estimate. The result was highly satisfactory from the owner's point of view but not from that of the contractor who carried out the work.

The new Road Rail Traffic Act (British) now limits the haulage contractor's fleet tonnage to what the Commissioners have assigned to him and granted him licenses for. He cannot increase his fleet. With a gasoline-engined fleet, the contractor's only hope of increased earnings is by converting his fleet, and it would appear that this conversion industry, as well as the proprietary engine manufacturer, should benefit considerably by this.

In the case of a well-known gasoline engine "A," the contractor obtains 85.86 gross ton-miles per gallon for 1s 3d, equal to 5.72 for 1 penny.

In the case of the Diesel "B," he obtains 320 gross ton-miles per gallon for 5d, which is equal to 64 for 1 penny, or over eleven times as much.

Sufficient mention has been made of all the advantages of the high-speed Diesel engine. One must, however, also mention the one real disadvantage of the Diesel. The worst made gasoline engine, even in bad order, will rarely emit dense volumes of heavy black smoke from its exhaust. The best Diesel engine in the world can easily be made to smoke. Bad or dirty fuel oil, the injection pumps in bad order, dirty sprayers, clogged piston rings, a stretched timing chain, carbon deposit in the cylinders and heads, and other simple causes will result in a smoky exhaust, more or less dense and more or less black, according to the trouble which causes it. When one comes to a poorly designed engine in addition to these troubles, then it is indeed disastrous. This does not necessarily imply that a Diesel engine requires more routine attention than a gasoline engine, but it does imply that the Diesel requires regular and ordered attention to keep it in good tune, and with a clear exhaust, vitally necessary for road transport work. At the present time there does not seem to be much hope of eliminating this disadvantage, so that it is of the greatest importance that all Diesel-engine users should insist on giving the engines the necessary attention, and thus avoid smoky exhausts. (Maj. W. H. Goddard, Diesel Engine Users Association Report No. S123, original article pp. 1–26, 24 figs., and discussion, pp. 27–34)

POWER-PLANT ENGINEERING

Changes in Existing Plant

THE title of the original article is "Power Developments at the Jersey City Plant of Colgate-Palmolive-Peet Co." It deals with the reconstruction of a plant undertaken to bring about its modernization and improvement in efficiency. In this connection a story is told to the effect that when electric power was introduced at the Colgate plant in Jersey City about 1896 an error in arithmetic, destined to have far-reaching consequences, was made. A 25-cycle belt-driven generator was installed and in figuring the pulley diameter somebody slipped up exactly 10 per cent. The result was a frequency of $27\frac{1}{2}$ cycles which is still standard for about two-thirds of the plant's power consumption.

In 1928 a new process for soap powder called for additional power in excess of the plant's generating capacity. In order to get the process in operation without delay it was decided to purchase power from the Public Service Company. The Colgate Company considered converting the purchased energy to parallel their own. With a direct-connected motor-generator set the least number of poles that would change the frequency exactly was 48 on the 60-cycle and 22 on the $27\frac{1}{2}$-cycle and at 150 rpm. This would have been a bulky and expensive machine. A 22- and 10-pole machine would make the change from 60 to $27\frac{1}{4}$ cycles and would have meant a scant 1 per cent slower motor speeds throughout the plant but even 1 per cent was enough to raise objections from production departments.

Some of the company's executives did not look with favor on the idea of investing more money in $27\frac{1}{2}$-cycle equipment. In the years since the first generator in-

stallation they had witnessed how the old controversy of 25 vs. 60 cycles and 2-phase vs. 3-phase current had been settled in favor of 60 cycles, 3 phase. All realized the advantages of adhering to a common, nation-wide standard, and it was finally decided to introduce a second power system in the plant of 60 cycles, 3-phase, 440 volts, distributed over three wires. At the same time it was decided to run the new distribution lines so that in the majority of future installations 60-cycle, 3-phase motors could be used. Since 1928 the 3-phase system has grown to exceed 1000 hp of installed motor capacity and 135 kw of installed lighting load.

The question of natural vs. induced draft was hard to settle. Two brick stacks were available, 275 ft high and maintained in good condition. It seemed odd to use induced draft in connection with such stacks. A low-draft-loss boiler and economizer could be made as efficient as a high-draft-loss installation by increasing the heating surface. The cost of this additional heating surface would only slightly exceed the cost of an induced-draft fan. It would be desirable to avoid the use of the fan from the viewpoint of maintenance, reliability, and power usage. On the other hand, induced draft could more easily be arranged to provide draft for overload conditions, and fitted better into the available space. Overload possibilities with induced draft finally determined the decision. (Gosta Anbro, paper before the Metropolitan Section, A.S.M.E., New York, March 27, 1935, abstracted through *Combustion*, vol. 6, no. 10, April, 1935, pp. 27–29)

Revamping of Connors Creek Station

WHEN Connors Creek Station of the Detroit Edison Co. was built some twenty years ago it represented the last word in power-plant engineering technique of its time. It was always maintained in excellent condition and was singularly free from shutdowns. In the twenty years of its existence, however, the art of engineering has advanced. From good practice of around 17 per cent in 1914 thermal efficiencies had increased to around 30 per cent in 1934, and whereas the heat rate of Connors Creek Station was around 19,000 Btu per kwhr, in 1934 stations 12,000 and 13,000 Btu were common. This led to the consideration of the possibility of improving the performance of the station by the use of modern equipment. The problem of conversion was not an easy one as the new equipment had to be fitted into the old shell, and as much of the existing equipment as possible retained. There is no space here to give a complete description of the changes made. The article is of great value to those who are interested in the history of power-plant engineering and the progress made in the last twenty years.

The changes in the boiler room were particularly thorough. New boilers capable of producing 330,000 lb of steam per hr were installed and occupied practically the same floor area as the old units which had a capacity of 121,000 lb of steam per hr. The boilers are equipped with double-ended underfeed stokers provided with a system of metered air control. The entire control of the boiler is centralized on the operating floor level. The boilers proper are special double-ended, bent-tube, six-drum, VV-type units having 26,746 sq ft of heating surface in the boiler proper. The furnaces are completely water-cooled.

The superheater elements installed in the two halves of the boiler are different —one consisting of a semi-radiant superheater in the first bank of tubes, and the other of a similar element in the first bank and a convection-type superheater in the second pass. This compensating-type superheater arrangement provides a constant steam temperature of 850 F ± 5 deg over the entire operating range.

The most interesting feature of the new installation is the automatic zone air control. This cannot be described because of lack of space. (*Power Plant Engineering*, vol. 39, no. 4, April, 1935, pp. 206–213, 10 figs.)

Brown Boveri Water-Jet High-Voltage Electric Boiler

THE principal feature of this boiler is that the electric current does not flow from immersed electrodes through a stationary column of water, but is conducted through water jets which radiate continuously from nozzles to the electrodes.

The construction and mode of operation of the Brown Boveri boiler is shown in Fig. 9.

A Brown Boveri electric boiler plant comprises essentially the boiler proper *a* with the built-in electrodes *b*, the ejection pipe *c*, a circulating pump with driving motor *d*, the usual boiler fittings, and the requisite switch-gear.

The three electrodes are arranged concentrically about the vertical ejection tube, which is provided with three vertical double rows of nozzles. The circulating pump delivers water from the lower part of the boiler into this tube, from which it flows in jets against the electrodes. These are so constructed that the water impinges on their inner surface tangentially, spreads over the inner surface, and is so deflected that it acquires a circulatory and downward motion. In this way, dispersion of the water, which would interfere with the electrical conductivity, is prevented.

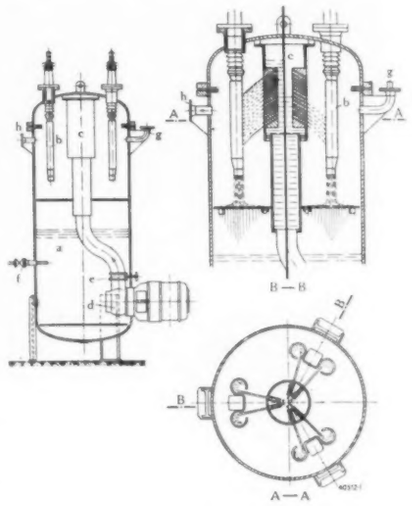


FIG. 9 THE NEW BROWN BOVERI ELECTRIC BOILER

(*a* = boiler; *b* = electrode; *c* = ejection pipe; *d* = circulating pump; *e* = throttle (regulating) valve; *f* = feed valve; *g* = safety valve; *h* = steam outlet.)

At the same time the centrifugal effect assists the separation of the steam produced from the water. At their lower ends the spiral electrodes become circular, so that a tubular extension is formed which collects the water caught in the spirals and concentrates it into a jet. A sheet-metal cross is built into this tubular extension to stop the circulatory motion so that the water leaves the electrode at the bottom in a compact downward jet. The water then impinges on a perforated plate, which is electrically connected with the side of the boiler, and flows through it into the collecting chamber.

In this manner two current paths of constant length are formed per phase between the neutral point of the electrical system, to which the boiler shell and the injection tube are connected, and the electrodes, one of the paths being between the ejection tube and the electrodes, the other between the electrodes and the aforementioned perforated plate. Along both of these paths the water is heated and evaporated due to its own resistance. Under normal operating con-

ditions the jet water is practically at evaporation temperature, as it flows continually in a closed circuit, so that a very small portion of the electrical energy supplied is used for heating the water, the major portion being used for evaporating it.

The only ceramic parts are the bushing insulators and they are not immersed in the water. This is important, as ceramic parts which are immersed in boiler water are subject to attack and have to be replaced from time to time. The output of the boiler is regulated exclusively by varying the quantity of circulating water. According to the output a greater or smaller number of nozzles is used. The boiler is normally built for operation with three-phase current of 2000 volts upward, and for outputs of 300 to 10,000 kw and more. A somewhat different arrangement described in the original article is recommended when the boiler is to be used as a hot-water boiler for supplying bath, heating installations, etc. The regulating gear and the electrical equipment are described in detail, this being followed by a comparison of the running costs of coal- and oil-fired boilers and the new electric boiler. (E. Soldati, *The Brown Boveri Review*, vol. 22, no. 3, March, 1935, pp. 71–76, 8 figs.)

PUMPS

Diesel Pump Drive

A METHOD of driving vertical deep-well pumps from Diesel engines by a simple flat-belt quarter-turn drive employing only one idler pulley instead of two has been developed by Harry M. Perry, of Los Angeles, Calif. The designer asserts that by a suitable tilting of the pulley combined with a corresponding cross angle of it in relation to the slack belt, this drive will run backward without running the belt off either pulley. This has heretofore been the cause of the ruin of belts in the event that the weight of water in the pump ran the pump backward when the engine stopped with no attendant at hand. (*Diesel Power*, vol. 13, no. 3, March, 1935, pp. 168, 1 fig.)

RAILROAD ENGINEERING

The Burlington "Zephyr" Streamlined Train

AS A background for the introduction of high-speed trains the author points out that the revenue from passenger business on the Class I roads dropped from $1,289,000,000 in 1920 to $329,000,000 in 1933. He points out further that while railroads never made much out of their passenger business, the loss of such an enormous sum was acutely felt, due to the fact that the cost of running passenger trains did not come down in proportion to the decrease in revenue. The true profit on most railroads was made in handling freight. If, therefore, a railroad could be used to its capacity for handling freight trains only without any interference from passenger trains, it would be more profitable than when handling both freight and passenger trains. However, it has cost almost as much to operate the trains with only a few passengers as it did with many, when a fair proportion of overhead expenses, together with a cost of maintaining road beds, tracks, and other facilities are included.

In the trains of the *Zephyr* type an effort has been made to attract passenger traffic by increasing the speed, and if possible reducing the cost of operation. As to the latter it is stated that the cost of operating the steam trains average approximately 65 cents per mile, as compared with 30 cents per mile for the cost of operating the *Zephyr*. The maximum speed of the *Zephyr* in service is 85 mph. Its main value lies however in the fact that its acceleration and deceleration are so rapid that a very high average speed may be maintained with a maximum speed not greatly above the average.

Some idea of the reason for this high acceleration and deceleration is indicated by the fact that steam-train equipment which the *Zephyr* replaced between Kansas City and Omaha had a weight of 809,000 lb as compared with the total weight of the *Zephyr* ready for service of 218,847 lb.

As for streamlining, at ordinary speeds, up to 50 mph, it accomplishes comparatively little in the way of economy in fuel or gain in speed, but for higher speeds the benefits increase very rapidly and at 100 mph the gain in speed due to streamlining is more than 30 per cent. The principal advantage, however, comes from the light weight.

There is a question in the minds of some as to the hazards at grade crossings. The power plant is carried over the front truck of a light-weight train, and in the case of the *Zephyr* there is more weight on its front truck than on the forward truck of our largest passenger locomotive. Any collision with even the smallest automobile may result in derailment of the heaviest train because some small broken part may raise the wheels off the rails. Instances of such accidents are only too numerous. The front of the *Zephyr* is shaped in such a way as to lift and deflect obstructions under the train. On several occasions it has struck animals on the track and it has had four encounters with highway vehicles at grade crossings, two with trucks and two with automobiles. In each case it cleared the track without derailment or damage—to the *Zephyr*. In this respect its batting average is 1000. (Ralph Budd in *The Atlantic Monthly*, vol. 155, no. 5, May, 1935, pp. 534–544)

STEAM ENGINEERING

The Velox Boiler

THE article is devoted to a description of the devices for regulating the various factors of operation of the Velox boiler, and presentation of performance tests. Among other things, the author says that as compared with old-style boilers enormous quantities of heat up to 300,000 kcal per sq m per hr, are transmitted in the Velox boiler, which led to apprehension that such a large flow of heat might affect the life and structure of the materials of the boiler. Iron and steel undergo transformation of structure first when they pass from a liquid state to a solid and next as a result of heating in the course of thermal treatment. In commercial mild steel all the important changes in structure occur at temperatures in excess of 700 C, which the materials never reach in the Velox boiler. The situation may be different, however, with parts which have been previously exposed to changes of shape, such as cold rolling or excessive thermal stresses. Where this has been the case mild steel becomes subject to recrystallization at temperatures as low as of the order of 400 C.

The main cause of destruction of the film surrounding the crystal is cold-working, such as drawing or rolling, which is not encountered in the parts under the greatest thermal stresses, particularly the evaporator and superheater tubes. Moreover, only well-annealed material is employed, so that there are two reasons why the highest wall temperatures of 330 C occurring in the evaporator tubes do not produce recrystallization. The superheater tubes consist of alloy steel of comparatively high heat resistance. That a very large flow of heat does not represent a danger in itself is shown by operating experiences in thermal power machinery. In the old steam engine which operated with saturated steam and a very low compression at the end of the stroke the live steam came into sudden contact with the

strongly precooled walls in the clearance space. According to E. Schmidt, the coefficient of heat transfer with drop condensation which inescapably occurred on the polished and oiled cylinder wall amounted to from 30,000 to 40,000 kcal per sq m per hr per deg C. With a temperature difference of 60 deg which he found by measurement to exist between the steam and the wall, the quantity of heat which was made to penetrate into the wall amounted to from 1.8 to 2.4 million kcal per sq m per hr. And the heat transfer in the numberless old steam engines was as great or greater without leading to trouble, because of change of structure of the metal.

The harmlessness of a very high transfer of heat is also demonstrated by modern Diesel engines, in which up to 2,000,000 kcal per sq m per hr periodically flow into and come out of the wall. It is true that the depth of penetration is only a fraction of a millimeter, but within that depth hundreds of thousands of molecules lie in layer upon layer, and their structure might be all the more affected, in proportion to the content of free graphite in the cylinder cast iron, causing the appearance of cracks. It so happens, however, that both experience and theory show that it is not this back and forth motion of the stream of heat, but excessive heat stresses which constitute a source of danger. On those parts of the Diesel no changes of structure have ever been observed, even though the outermost wall layer may attain a temperature of the order of 330 C. The author states that he has carefully calculated the mechanical and thermal stresses in the parts of the Velox boiler most stressed and has come to the conclusion that these stresses are permissible in so far as the physical properties of the materials used are concerned and that they lie well beyond the yield point determined by a rupture test. (Prof. A. Stodola in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 79, no. 14, April 6, 1935, abstracted part on p. 432, the whole article on pp. 429–436, 16 figs.)

TESTING AND MEASUREMENTS

The Edmmus System of Units

THE intention of this system is to replace the present cgs electric and magnetic units by a new system where the following fundamental units are used:

Mass = 10^{-11} *g* (as in the Q.E.S. system)
Length = 10 cm (1 dm)
Time = 10^{-6} *s* (1 microsecond)

The name Edmmus is composed of "E" symbolizing the use of the eleventh power; "DM" the decimeter; and "MUS," the mu-second or microsecond.

While mechanical units expressed in the new system are given it does not appear that they will be utilized and cgs units will probably continue to be used in mechanical measurements. Under these conditions a complete abstract of the article will not be justified. (Louis Barbillion and Maurice-Denis Papin in *L'Industrie Electrique*, vol. 44, no. 1024, Feb. 25, 1935, pp. 77–81)

Motion Analysis by High-Speed Motion Pictures

THIS article deals primarily with the application of this method of analysis to the design and operation of textile machinery. The camera used gave up to 200 pictures per second, the time of exposure being from $^1/_{5000}$ to $^1/_{10,000}$ sec. When these pictures were projected at the rate of 16 per sec it was equivalent to slowing down the speed of a mechanism to one-twelfth of its actual speed. The original article tells how the method described was applied to the study of a loom, the motion of a shuttle, and to the operation of cams, and metal picker sticks. The same method was applied to the case of shoe machines and on the screen the motion of two plungers which had been supposed to be coincident was found to be far from it. In a steel mill the same process has shown reasons why the operation of flying shears was not right, and how to correct the trouble. (Floyd A. Ramsdell, Gen. Mgr., Worcester Film Corporation, and Albert Palmer, Asst. to Gen. Mgr., Crompton and Knowles Loom Works, in *Machine Design*, vol. 7, no. 3, March, 1935, pp. 13–17, 9 figs.)

Inspection of Engine Parts by the Magna-Flux Method

THIS method is being used in the inspection service of the Bristol Airplane Co. in the manufacture of aircraft engines and is said to reveal cracks by the concentration of iron particles under the influence of a magnetic field. It can be used alone or in connection with etching. It is said that the actual method of carrying out the tests is very simple and requires no particular skill, since any cracks are plainly shown up.

The apparatus consists of a large coil energized by direct current and incorporating a solid core and adjustable sliding pole pieces across the gap of which the part under test is placed. The piece tested, freed from grease, oil, and carbon is placed on the pole pieces in such a position that the field of force is at right angles at the expected crack. With the current switched on, a liquid containing minutely divided iron particles, known as "detector ink," is poured gently over the components with the aid of an aluminum ladle, and any cracks are revealed by the accumulation of iron particles on the edges through the local disturbance of the magnetic flux. The crack is sharply defined and may be quickly confirmed by a second test.

After aircraft-engine parts have been subjected to this treatment in an intensive magnetic field, it is of great importance to dispel all residual magnetism within them. This demagnetizing process is effected by passing the components through a field of demagnetizing coil which is energized by alternating current. Parts of irregular shape, such as gears, are turned around while in the field, so that all the various portions are properly subjected to the demagnetizing influence. (*The Engineer*, vol. 159, no. 4130, Mar. 8, 1935, p. 249, illustrated)

The Bend Test as a Guide to Ductility

IN AN important paper, of which only part of the summary can be reported here because of lack of space, it is claimed that a bend test of a welded joint affords an excellent means of assessing the ductility of the weld metal.

For a commercial test the convenient means of testing for minimum ductility is by measuring the strain developed by a transverse test piece. The curves in the original article show the relationship between the severity of a test and the width of a specimen. When the ductility is high the strain required to form a crack in a narrow specimen reaches three times that required for a wide specimen and when the ductility is very low twice the strain is still required. The elongation given by a close bend decreases when the width is increased or the thickness reduced. Its value increases with the strength of the material. A small angle of the bend should not be specified.

The results from such tests are reliable only if material of a given grade has been bent to a pure bending moment under defined conditions, and conditions applying to bending on a former are enumerated. In any method of test there is no need for the total angle through which the specimen has been bent to reach 180 deg. Bending with a former need not be continued after 120 deg is reached, or bending on a mandrel when correctly

performed, after 100 deg. Where, however, the full-bend test is adopted the final internal diameter should not exceed the prescribed diameter. The ductility of the weld metal within a fusion-welded butt joint is readily determined from a bend test. If no measurement of strain is made the specimen must be cut out longitudinally from the joint. For a commercial test on a transverse specimen measurement of the elongation is essential and the limitations of such a method are described in the original article. (L. W. Schuster, paper before the Institution of Mechanical Engineers, presented March 26, 1935, abstracted through *The Engineer*, vol. 159, no. 4134, Apr. 5, 1935, pp. 354–356, 3 figs., discussion, pp. 360–361)

TEXTILE ENGINEERING

The Effect of Cation-Active Fatty Materials on Vegetable Fiber

CATION-ACTIVE fats are surface-active materials of the fatty series which carry the fatty chains responsible for the surface activity in the form of cations. Contrariwise, the surface-active materials which carry the fatty chains in anions are called anion-active. The majority of surface-active materials which we know are anion-active, the cation-active group being very small, as shown in the original article.

The cation-active fatty materials emit into the water solution positively charged surface-active cations. These collect at the surface of the solution and discharge or displace everything encountered there and carry either negative or positive charges. Notwithstanding the fact that water solutions of these bodies foam, they cannot be used instead of soaps in the washing process. They do not emulsify peptized particles of dirt which are mostly negative, and have, therefore, no cleansing effects. Nevertheless, they have important applications of their own in various branches of the textile industry, and permit the attainment of novel effects because of their ability to discharge or precipitate negatively charged suspended particles. If a suspension of lampblack in water be displaced by a suspension of an anion-active body, the particles of lampblack are peptized because they take a negative charge. If, however, a cation-active material is introduced into a lampblack dispersion, the particles of lampblack are deprived of their charges and precipitate out. This ability of cation-active material finds practical application in the purification of waste water and destruction of stable emulsions. Had there been present in the system, in addition to the dispersed lampblack water system, a foundation material, such as a textile fiber, the particles of soot would have been precipitated on to this foundation material, and dyed it equally and uniformly. If instead of lampblack a fatty material were present in the state of emulsion it would also have been uniformly precipitated on to the foundation material.

The described phenomena provide a basis for numerous practical applications of cation-active materials. There is a further valuable possibility of surface-active cations which may also be utilized. It has been observed that the cations collect on the boundary surface and, for example, adhere to the surface of vegetable fiber so powerfully that they cover it as by a film and endow it with properties of a positively charged foundation body. This makes the cotton fiber substantive with respect to all negatively charged particles, but this substantivity may be reduced the desired extent. The film of cation-active material may be reduced in thickness by a proper addition of anion-active substances, or it may be completely discharged and withdrawn, which means that the fiber acting as a foundation material may be endowed with any desired degree of substantivity. The precipitation of negatively charged particles can be carried rapidly in coarse dispersion or slowly in a fine dispersion and with good equalization. As an example of such coloring by control of charges may be cited the case of a viscose artificial silk thread which may be dyed by means of freshly precipitated ferri-hydroxide to be resistant to water, light, and friction. Several other features of cation-active materials are discussed and radical possibilities in the field of vat dyes are pointed out. (Dr. H. Bertsch in *Angewandte Chemie*, vol. 48, no. 2, Jan. 12, 1935, pp. 52–53)

VARIA

Decimal Dimensioning Adopted by Ford

THE Ford Motor Company has adopted a decimal system for basic dimensioning to replace common fractions. It applies at present to all parts except bores requiring the use of standard-size reamers. It is claimed that this makes addition and subtraction of dimensions easier. When tolerances are required the figures definitely indicate this requirement by the addition of two or three digits to an already existing decimal, rather than having a converted common fraction to or from which the working elements have been added or subtracted. In other words, the system does not entail so much substitution of decimals for common fractions as it does a complete change to thinking in terms of tenths instead of fractions. For easy application of this system new scales have been developed with common fractions replaced by calibrations in tenths and fiftieths of an inch, the latter having been found preferable to one-hundredths, due to the easier visibility of the dimension. The original article shows such a scale and a drawing with decimal dimensions. It is reported that one or two tap and die manufacturers are already considering the production of such tools to a decimal basis. (*Industrial Standardization*, vol. 6, no. 1, January, 1935, pp. 24–25, 2 figs.)

The Share of Labor in Industry

FROM data collected by the National Industrial Conference Board it appears that if it were possible to trace all the payments for wages and salaries that go into the product through such incidental expenses as insurance, advertising, financing, and the like, together with labor expended in production and transportation of materials, fuel, and supplies before they reach the factory, it is probable that in the final value of the product the share of payments for labor would exceed 65 per cent. In other words, 65 cents out of every dollar, on the average, paid by American industry for its machinery and equipment, goes for labor in the form of wages.

From a recent survey by the Machinery and Allied Products Institute it has been determined that there exists a pent-up demand for machinery amounting to $18,574,000,000. A simple mathematical calculation makes it possible to determine what this pent-up machinery means to labor.

Sixty-five per cent of $18,574,000,000 is $12,073,000,000. In round figures, therefore, twelve billion dollars represents the payroll cost of producing machinery and equipment required at the present time for the modernization of American plants.

How much labor is twelve billion dollars' worth?

Actual wage rates paid in machinery manufacture vary widely, running the range of service from unskilled workmen to highly paid experts. The average hourly rate of pay may be estimated conservatively at 60 cents in the machinery industries and a calculation on that basis reveals that the $12,073,000,000 payroll

would purchase 20,123,000,000 hr of labor, in round figures.

Another calculation shows that 20,123,000,000 hr represents the work of one man, 8 hr a day and 6 days a week, for about 8,000,000 years—or employment of 8,000,000 men for one year, or of 4,000,000 men for two years. There are somewhat more than 4,000,000 persons unemployed in the capital-goods industries. These would find demand for their services if the potential machinery requirements of the country were to be met, and such reemployment would have a profound effect far back of the machinery plants in the realm of raw material and transport and all intermediate processing, for it is estimated that for each man actually at work in machinery manufacture three others find work therefrom. (Survey of Machinery Requirements, dated April 4, 1935, and issued by the Machinery and Allied Products Institute, Chicago, Ill., 19 multigraphed pages)

Factory Training Courses

THE Hobart Manufacturing Co. at Troy, Ohio, is said to have adopted an extensive replacement policy at a time when most other concerns were decreasing their purchases. Next came the problem of providing well-trained and highly skilled operators. Troy, Ohio, is a city of 10,000 population. There is no labor pool on which the company can draw to meet its needs and the company did not like to hire men from other cities and bring them to Troy.

To meet this situation the company inaugurated its own training program in conjunction with the Smith-Hughes program of the State of Ohio. Applicants for the course must be at least 18 years old and have a high-school education or its equivalent. The course is designed to take two years and consists of 4000 shop hours and 450 hours devoted to classroom work. Broadly, the subjects treated in the classroom are mathematics, science, shop information, and blueprint reading.

These broad subjects are divided into such things as the study of ferrous and non-ferrous metals; tempering and heat-treating and its effects; tests and testing hardness; lubrication; cutting fluids; power transmission; shop safety; grinding wheels, polishing and buffing; plating; paint; shop information, organization and personnel; management, including explanation of fixed investment, operating expense, and waste elimination; foundry practice; motors; machine-shop practice; use of scales, squares, and rules; mathematical computation from working drawings; measurement of threads; use and construction of charts and tables; layouts involving areas; plane geometry; simple and compound gearing; calculation of cutting and grinding speeds; graduated dials; calculating tapers; mathematics of gearing; shrink fits; precision instruments for measuring, slide rules; free-hand sketching; orthographic projection and the care to be exercised in making drawings.

When the course was announced there was considerable curiosity as to its reception by the employees. A limit of 18 students was set for the first year. Within 24 hours after the announcement was made, 25 men had asked to be enrolled with every possibility of additional applications coming in. The problem which now confronts the company is how to take care of all the employees who are qualified to take the course and who have indicated that they would like to do so. (J. M. Spencer, Vice-President, Hobart Manufacturing Co., in *The American Machinist*, vol. 79, no. 6, March 13, 1935, pp. 225–228, 4 figs.)

Industrial Reorganization Plans in England

THIS article deals primarily with the Industrial Reorganization (Enabling) Bill recently introduced in the House of Lords by Lord Melchett, son of the first chairman of Imperial Chemical Industries, Ltd., the largest corporation of its kind in England. The bill itself deals primarily with the reorganization of chemical industries though apparently not limited to this one subject. It is quite extensive and not suitable for abstracting, except for one feature, and that is, provision for new entrants into the industry.

In this connection two of the largest industrialists in England remarked to Lord Melchett that they could not see how their respective fathers could have started up the great businesses they now controlled if this bill had been in existence at the time. Lord Melchett's answer is that this was perfectly true; they could not have done so. Those were, however, the pioneer days of industry when it was possible to have a new industry come along and entirely and completely, after a comparatively short number of years, displace another industry. Industry today was so highly complex and so closely interwoven that it was not to the benefit of industry as a whole that a death blow should be dealt to any important industry. It was much more valuable to the community as a whole that what progress was made—and progress would continue to be made whatever steps they took—was made with some regularity and with some hope that those who had already sunk large sums of capital in employing large numbers of men and occupying an important part of the economic functions should be given the opportunity of dying decently instead of violently. It was better that new entrants and new processes should be brought in in some order instead of by violence and disorder.

That was one side of the matter, and the other side was that in point of fact the progress of industry today was made in rather a difficult way. One did not find new processes coming along and entirely displacing the older processes. One found much more that as the result of a much larger amount of research a constant, continual, sometimes rapid and sometimes slower progress was being made in every industry. He did not think they need fear that that progress would not continue. What they had to fear, however, was that that progress might be rather more rapid than they could digest.

Lord Melchett also said he thought it was necessary to preserve the balance between the danger of a large number of new entrants and the danger of shutting them out altogether; the latter was the greater danger of the two. (*The Chemical Age*, vol. 32, no. 814, Feb. 2, 1935, pp. 91–94)

The Electronic License Situation

AS A result of considerable litigation a consent decree in the Federal suit against the Radio Corporation, General Electric, and Westinghouse companies and their associates, was entered. This creates a situation which may be of interest to engineers in other fields of activities. In particular each company is free to license applicants under its own patents. Thus, the American Telephone and Telegraph is the only one of the group which can grant licenses under all of its patents in the fields relating to radio communication in any form, including the broadcasting of programs over wire lines, with certain exceptions, and two-way voice communication. It is also, however, free to issue licenses under its own patents in these or any other fields. On the other hand, the four companies agree to exchange licenses, and, in some instances, to grant sub-licenses. (*Electronics*, May, 1935, pp. 143–144)

LETTERS AND COMMENT

Brief Articles of Current Interest, Discussion of Papers, A.S.M.E. Activities

Study of Technical History

To the Editor:

In the March, 1935, number of Mechanical Engineering, Mr. I. N. Liphshitz presented in his paper "The Study of Technical History" in a very satisfactory way, the general outline of this important undertaking and while one might further discuss and perhaps add to the material contained therein it seems more desirable to direct attention to the importance of preserving structures and machines to serve as exhibits showing steps in evolution and advancement. Such exhibits would not only serve the purpose of accurate and reliable records but would also tend to render unnecessary the loss of effort involved in the rediscovery of engineering applications of science and the recreation of methods and devices.

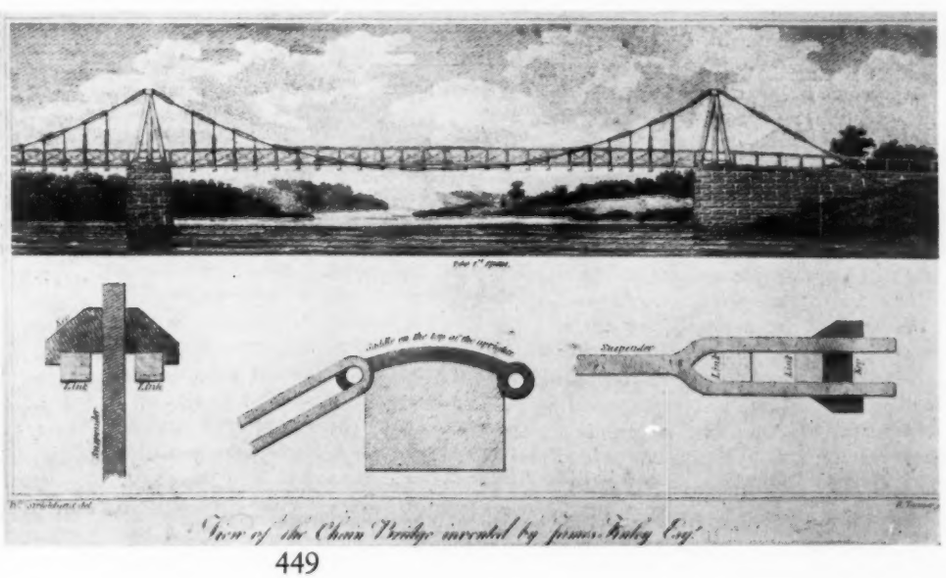
It is recognized that the preservation of large machines and structures involves, in general, a considerable expense, especially when they must be placed in buildings or otherwise protected from the weather. However, there are instances wherein the upkeep involves only a moderate expense and still others wherein there may be an actual return through use. It is further recognized that to evaluate the advantage to our own and future generations through the preservation of engineering antiquities is especially difficult. However, they, like other art treasures, possess intrinsic value. As examples illustrative of the conditions herein mentioned the following have been selected:

At Troy, N. Y., there exists the ruins of a water wheel credited to be the greatest in power capacity of wheels of the overshot type. Its diameter was 60 ft and its width 22 ft. The 36 buckets upon its perimeter extended the full width of the wheel, providing an operating capacity of 1200 hp. Through weakening of its timbers by decay it collapsed a few years ago under the pressure of an accumulation of snow. However, its metal-work portions of cast and wrought iron are intact although the wrought-iron radial stays and braces are bent. Its timber work is still in a satisfactory condition to permit exact duplication and a small portion could be salvaged and reused in its reconstruction. The large cast-iron flywheel used in conjunction with the water wheel is intact and in satisfactory preservation. The wheel was built in 1838–1839 by the Burden Iron Works, its design being attributed to Henry Burden of that company. At that time the major activity of the company was the manufacture of horse and mule shoes and nails, and later, when the American Civil War was in progress, this concern supplied of these materials a large portion of the needs of the Union Army.

At Lehigh Gap, Pennsylvania, there existed a Finley-type chain suspension bridge which was replaced by a modern structure in 1934. It is regrettable that the chain structure was not carefully disassembled, reerected, and properly identified by markers in one of our national parks. The patent rights for this type of bridge were granted to James Finley, Fayette County, Pennsylvania, June 17, 1803. It is generally conceded that in the construction of the bridge over Jacobs Creek near his home in 1801, Mr. Finley originated the metal suspension bridge as it is now constructed, that is to say, with a horizontal floor system suspended from suspension members. The accompanying illustration reproduced from Mr. Finley's pamphlet shows the important details of his invention. The bridge at Lehigh Gap, Pa., was the last existing bridge of the Finley type and its preservation would, therefore, have been a meritorious act.

Near Harpers Ferry, Virginia, there exists a single-span railroad bridge of the type patented by Albert Fink, March 3, 1857. The details of its construction render its disassembling and reerection a relatively easy matter. It could well be remodeled for highway service in a national park or elsewhere at a location where the traffic service would facilitate the use of a narrow bridge. Very few structures of the Fink type are now in existence.

Although the credit for inventing the first American metal bridge properly belongs to Thomas Paine and although we may justly regard James Finley as the "father of the metal suspension bridge," great credit is due Squire Whipple for having developed and patented in 1841 and 1846 two early types of American truss bridges which secured wide adoption. A comparatively small number of Whipple truss structures still remain in service. It is very desirable



View of the Chain Bridge invented by James Finley Esq.

that at least a part of these be preserved as antiquities and memorials to the engineer who produced in 1847 the first American book treating scientifically the elements of bridge design and who probably did more to advance this science than any other American engineer.

Near Great Falls, Va., and closely adjacent to the Potomac River there was built, in 1786–1796, the "Potowmack Canal" by a company having George Washington as its president. Authentic records indicate that as an engineer he devoted much time to this project although he received no pay for his services. The canal consisted essentially of two sections, one at Little Falls about four miles above Washington and the other at Great Falls about twelve miles distant.

At the latter location there were five locks by which a total elevation of 86 ft was attained. Two of these were located in a solid ledge cut and required no masonry walls but the remaining three, each one hundred feet in length, were walled with ashlar masonry, a portion of which is still intact and in generally good condition. However, its future preservation should be insured by a moderate amount of repointing and other repair. Naturally, none of the woodwork now remains and in addition the castings and other metal work of the gates and sluices have disappeared. The portions of the canal prism together with the lock walls now existing should be preserved as antiquities of early river navigation improvement and as a material record of the efforts made by George Washington to procure the essentials requisite for the development of a new nation.

To provide means whereby engineers may come to their problems with an accumulation of the past and successfully meet them with the constructions and purposes they desire to bring to pass is both a commendable and worthy undertaking.

LLEWELLYN N. EDWARDS.[2]

Comments on E.C.P.D.

TO THE EDITOR:

On March 6 the writer attended the joint meeting[1] of the engineering societies at which was presented an outline of the plan of the Engineers' Council for Professional Development, and listened attentively to the addresses of the scheduled speakers and to the fragmentary comment from the floor.

There was much loose talk anent the "status of the engineer," "increased recognition," and other intangibles which no one undertook to define in precise terms. There was notable absence of that "engineering precision of thought" of which we boast so much but which appears to serve no other purpose. There seemed to be a vague idea that engineers as a group might be grasped by the hair and lifted bodily to a higher business and social level.

The only sane pronouncement made during the whole evening was one by the chairman, Mr. Gano Dunn, and for some reason he thought it necessary to apologize to the speakers for that. He said, in substance, "the engineer now has all the recognition he merits."

What is all this talk about "recognition?" Recognition of *what* and by *whom?* Recognition that the engineer's work requires special training? So does a bricklayer's. Do we seek recognition from the man in the street, the crowds that ride the subways, the throngs that fill the cinemas? What would it signify if we had it? Does recognition mean newspaper ballyhoo about the wonderful things accomplished by engineers and the awful plight in which society would find itself without them? If not, what *does* it mean?

The sober fact is that the only recognition that counts, and what every engineer has in the back of his head when he talks about it, is recognition by the client or employer in the form of material compensation for services rendered. Despite all sorts of deals—square, new, or raw—this compensation is determined by the good old law of supply and demand. The labor-union movement was an attempt to evade this law—with what degree of success is pretty generally understood. But Dr. Hirshfeld expressly and quite emphatically disclaimed any intention on the part of the Council to import labor-union ideas or methods to engineering circles.

There are and always have been outstanding engineers (never many at any one time)—men of superior vision and mentality—and these have been the men selected when any unusual or peculiarly difficult problems were to be solved. Presumably they have been compensated in suitable proportion to the importance of their work, and the engineering and business world has given them due credit for their accomplishments.

But, notwithstanding a great deal of high-sounding talk about "the profession," 90 per cent, or more, of all engineers are in the class of skilled mechanics. They work at a "trade" as indubitably as does the carpenter or the machinist. Their tools are certain "accepted formulas" and "standard practices" which they apply in conventional ways; their results are just what any one else would get by the same methods, and they know no others. By far the greater number will always be in this class—somebody's assistants to do the routine work—to design and build structures and machines which differ in no essential from hundreds or thousands of predecessors.

The status of the engineer is strictly an ***individual*** matter. Each engineer will receive the recognition to which he is entitled by reason of ***his*** abilities and ***his*** accomplishments. It will do him no good to clamor for it solely on the ground that he is a member of a class or group which includes some distinguished men.

While the writer does not presume to act as interpreter for Mr. Dunn, it seems fair to infer that he had in mind something of this sort.

Individuality of thought and action is the distinguishing characteristic of the professional man. To the extent that he descends to mass action and standardized thinking he becomes non-professional. The man who makes loud demands for the elevation of his group is in reality trying to use the influence of that group to raise his own status above the point which his individual qualifications warrant.

If one should discuss merchants as a class he would include every one from the owner of a great department store to the proprietor of a six-by-nine hole-in-the-wall who purveys desiccated cigars and lurid literature for the intellectually destitute. Talk about the "status" of the merchant would be senseless.

The legal profession comprises a few scholarly and outstanding lawyers along with the hordes of attorneys who infest the lower courts. They are all members of the bar, but they have nothing else in common. What is meant by "the status of the legal profession?"

Every business, profession, or trade is graded. At the top are a few exceptional men, while the lower ranks are

[1] See MECHANICAL ENGINEERING, April, 1935, pp. 266–267.

[2] Senior Highway Bridge Engineer, U. S. Dept. of Agriculture, Bureau of Public Roads, Washington, D. C.

packed and jammed with mediocrity or worse. Improvement of status is a problem for each individual. When a man becomes class conscious he never thinks straight and he is never honest with himself. There are, and for many years have been, ample facilities by which any engineer may develop his capabilities to the utmost. Appointing committees and councils, passing resolutions, and generally sputtering about being unappreciated, will not raise the general level. Engineers would do well to bear in mind an elementary principle of mechanics—the motion of the center of gravity of a system is not affected by the action of internal forces.

Professor Barker's address was characteristic of the pedagogical view point. "Recognition" is to be based on an examination, said examination to take the form of a thesis or report on some engineering work executed by the candidate. An aspirant may "advance to be recognized" four years after graduation from a technical school. How many men at that stage of their careers can honestly point to *any* engineering work as their own? They have been merely assistants, and that is nothing to their discredit. An engineering work of importance is not a one-man job. Who shall decide to whose record it shall be credited?

There are and always will be aristocrats among engineers. They are and will be the men whose qualifications and accomplishments put them in the lead. Any attempt to set up an artificial classification will result only in a vulgar scramble of the canaille who will seek by devious and underhand methods to be included in a group where they do not belong. In the end mediocrity will dominate, and the move will defeat itself, just as good society has always been ruined by social climbers who thought that "front" could replace foundation.

Experience with licensing or registration of engineers in various states is illuminating. Almost anybody was admitted at first on the basis of very ordinary records adroitly dressed up with sonorous titles. As soon as a considerable number got on the inside they busied themselves to exclude as many others as possible, seeking to make themselves by statutory process what they could not become by virtue of their own attainments, viz., a professional aristocracy.

If the engineering societies are to continue their usefulness, they must restrict themselves to the activities for which they were organized, i.e., the interchange of engineering experiences and the dissemination of scientific and technical information. The position and "recognition" attained by each engineer will always depend solely on his own capabilities and the use he makes of the facilities at his command.

CHARLES W. COMSTOCK.[3]

TO THE EDITOR:

I have read Mr. Comstock's letter with great interest, particularly because it shows that I did not get my message across. I thought I had and that makes it particularly disappointing to me.

All that Mr. Comstock says is true and quite in line with my own thinking except that he appears to me to miss the vital point of the matter. It is certainly true that engineers will always be graded, not only by inherent ability but also by opportunity. However, there is a certain mean or norm or whatever you want to call it for the profession as a whole measured in any terms you care to use, compensation, achievement, intelligence, usefulness, what not. This can certainly be raised by improving engineers as a class. And, that is the basic aspiration of E.C.P.D. as I see it.

If we may adopt one of Mr. Comstock's figures, every body has a center of gravity. Some parts of the body are at greater elevations and some at lesser, some above and others below this center. Properly directed forces can raise the body as a whole without changing the distribution of its elements sensibly provided the forces are not of too great magnitude or too suddenly applied. That is all that E.C.P.D. can hope to do.

Now, it is perfectly true that I assume forces acting outside the body which Mr. Comstock objects to. I think we have here just that sort of distinction that E.C.P.D. is emphasizing. When we pass from the purely technical to those things having to do with man, we get into new kinds of forces which simple mechanical analysis does not comprehend.

For example, no one particle of our assumed body can, by voluntary choice, educate itself, acquire experience, and do all those other things required to raise it above the "level" of its fellows. But, any human being who is not unfortunately and excessively unendowed in some way can do so.

As I see it, the premise upon which we are working in E.C.P.D. and which I tried to put in words at the meeting Mr. Comstock refers to is this:

We can by careful planning and execution make the engineer a better and more roundly educated individual without detracting from his present technical ability. And, if we do this he must of necessity become a more useful member of the race. And if he does he is bound to rise as a class with respect to the other classes. We may measure such rise in any way we like, compensation, public opinion, self-satisfaction, what you will.

What Mr. Comstock says about supply and demand as fixing compensation between competitors in any single group is correct. But, the way in which compensation of that group shall compare with compensation of other groups is an entirely different matter. Among other things, it is determined partly by the usefulness of the group in comparison with that of other groups. To take an extreme case, I doubt that an expert chipper of flint arrow heads could command any large compensation in a modern, industrialized community.

C. F. HIRSHFELD.[4]

The Correct Economy

TO THE EDITOR:

In your editorial of the April number which refers to Professor Freeman's review of my book, "The Correct Economy for the Machine Age," you state that "in the discussion of engineering problems we like to feel that we have more positive, and possibly simpler, laws to deal with than seem to operate in the fields of economics and social relationships."

The laws of economic and social relationships are not positive and simple because the orthodox economy with which they are used interferes with the first law of nature and man's right to enjoy a standard of living in keeping with his desire and ability to produce.

The wants of man are insatiable and no nation can ever produce by the most efficient organization possible the equivalent of more than its people would like to produce and consume. If our economy functioned naturally and in harmony with man's nature there would always be a shortage of labor and capital on the whole to produce the goods and services for which there would be a firm and ever-increasing demand. Under an economy consistent with man's nature a shortage of labor and capital would be constantly felt. Labor would be in demand at high wages, and new capital would be in

[3] Jackson Heights, Long Island. Mem. A.S.M.E.

[4] Chairman, Engineers' Council for Professional Development. Chief, Research Department, The Detroit Edison Co., Detroit, Mich. Mem. A.S.M.E.

demand at high interest rates, and each worker would be able to pick and choose his employment, and each capitalist would be able to pick and choose the employment for his capital—economic liberty would rule.

The experience of the United States between the years 1921 and 1930, while it was accidental, offers the best example in history of a near approach to the correct economy. In the midst of depression Mr. Henry Ford started a fashion in raising wages which was forced upon other employers, with the result that wholesale prices quickly rose to a satisfactory level that has not been exceeded since except for a few months in 1925 and 1926, and prosperity was soon in full swing. Then as volume production and the use of better manufacturing methods swelled the profits of employers, wage and salary earners *fortunately* demanded higher pay and thus increases in consuming power followed increases in productive power.

Also during that period another very important factor was operating. Free competition, which is the life of trade, was constantly stimulating a demand for more and better productive facilities and thus there was a strong attraction between the new capital created and labor, affording employment for both in the production of producers' goods. Unfortunately, however, wages were not high enough, and the dollar was tied to gold. If wages had been higher, wholesale prices would not have started declining in 1926, consumption would have kept step with production and there would have been safe employment at home for capital recklessly loaned abroad. If the dollar had been cut loose from gold and allowed its natural exchange rates, United States' prices would have been free from external depressing influences.

If the United States Government had had the vision and the authority in 1927 to announce that it proposed to keep the United States power to consume in step with its power to produce by decreeing an all-round rise in wages and salaries from time to time in order to maintain the 1926 general price level firm under free competition, and if it had cut the dollar loose from *artificially fixed* exchange rates, and had announced that the Treasury would assume responsibility for the dollar's exchange rates, and that all United States exchange transactions must be cleared through the banks designated as its agents, and had insured the *natural* exchange rates for the dollar which would have kept United States exports in approximate balance with imports, there would never have been any lull in the prosperity of the United States. The prosperity it was enjoying then would have been a poor imitation of the prosperity and sense of security it could have been enjoying today.

Under industrialization, wage and salary earners hold the dominating consuming power, and if consuming power is to be kept in step with productive power to the great advantage of capital as well as labor, wages and salaries must be raised whenever the existing claimants of the returns from industry are unable to consume all that is produced.

Whenever prices have ruled at a certain level for some time as they did during the War, and in the "Gay Twenties," and then fall materially below that level, prosperity cannot be restored in any reasonable time without restoring the former general price level. This is true for several incontrovertable reasons which space does not permit elaborating.

Prices canot be soundly raised without increasing the costs of production or increasing the demand for goods. Then why not kill two birds with one stone by raising all wages and salaries? Professor Freeman disagrees with this recommendation of an engineer, and in a sweeping statement says that "of all the means which have been proposed to stimulate an advance in prices the raising of wages and salaries by fiat of the Government is the least defensible," and he says this in spite of the fact that Mr. John A. Hobson, a most eminent British Economist, after a careful study of the book, contributed a one-thousand word foreword in which he unstintingly praises and endorses its proposals.

Professor Freeman refers to the failure of the efforts of the NRA to raise prices by raising wages in 1933. The Government *never* announced that it would take control of the buying power of the dollar, a Government responsibility, by decreeing rises in all wages and salaries from time to time until the 1926 general price level was restored under free competition, and that it would peg the buying power of the dollar at that level by the use of the *only possible means*.

Professor Freeman worries about the effects of raising wages in the different industries and states that the prices in each industry should be restored to their former levels. This is impossible. When the Government assumes responsibility for keeping the *general* price level at the 1926 level, from which would follow automatically a balance between consuming power and productive power it is going far enough for the best interests of all concerned. There can never be a better agency for ironing out the troubles of the individual industries than the free operation of *supply and demand* when wages and salaries are paid on a scale that will maintain the *general* price level of 1926 firm under free competition. Far too many workers have been driven into trying to eke out a living on the land. The farm problem will be solved only by a demand in the other industries for some millions of workers now on the land. Furthermore, each employer would benefit if he and all his competitors and all other employers throughout the country raised wages by the same flat percentage. It must be remembered that while wages are an important item in the cost of production, they are the most important item in the consuming power for the goods produced, and employers on the whole can reap the highest profits only if consuming power is kept in step with productive power.

Professor Freeman suggests that I propose to penalize efficiency by raising wages most in the most efficient industries, whereas no such suggestion is made in the book. I state that in general after prosperity is restored, "The Wage Board" would decree rises or withhold rises to each craft or each district of the nation in harmony with the law of supply and demand allowing rises in cases where there tended to be a shortage of workers and withholding rises in cases where there tended to be a surplus.

Professor Freeman tries to distinguish between the distribution of the consuming power liberated by the production of producers' goods and that liberated by the production of consumers' goods. The relative proportions falling into the hands of the workers in the two cases is immaterial, the larger part falls into the hands of wage and salary earners in both cases. While the workers demand consumers' goods directly, that demand is translated into a demand for producers' goods indirectly. The higher the pay of workers the higher is the demand for producers' goods which will increase production and save labor, and the prices of producers' goods are quite as important to the consuming masses as are the prices of consumers' goods.

When prosperity is restored it can be maintained only by raising wages and salaries as the benefits of better efficiency and volume production tend, as they naturally do, to lower prices.

A dollar of constant purchasing power—a steady general price level—at the 1926 level can be maintained by no means other than by control of the general wage and salary level, and to try to control the buying power of the dollar by any other means is on a par with trying to make the tail wag the dog. Lowering wages and lowering consuming power when prices fall and permitting rises when all are comfortably employed and prices tend to rise is exactly the wrong procedure for success under industrialization.

Instead of interfering with supply and demand by price-fixing, restricting output, doles for both capital and labor, etc., to ameliorate the evils of falling prices when consuming power gets out of step with productive power, the Government should merely assume responsibility for restoring the balance between consuming power and productive power. To assume that responsibility, a responsibility which only the Government can perform and to free itself from all the other endless tasks it is ill-fitted to perform but which it is trying to perform, is the simple change in our economy *which must be made* if the tremendous benefits possible to all in the machine age are to be enjoyed.

Industrial peace and any degree of success in the machine age are impossible under the haphazard and unscientific "dispute" method of adjusting wages. An employer and his employees are incompetent to adjust wages in harmony with the best interests of all concerned.

Our economic forces are as real as any forces in nature and when we have an economy in which economic liberty rules under a balance between consuming power and productive power, and when workers enjoy security against poverty in their old age, as they should through a small tax on all pay rolls, we will find that the laws "operating in the field of economics" are quite as positive and simple as those we rely upon in our engineering problems.

A. G. MCGREGOR.[6]

Oil Burners and Boilers

TO THE EDITOR:

The paper by Professor Seeley[5] ably deals with a phase of domestic heating of importance to the manufacturers of oil burners and domestic heating boilers.

The author has pointed out the need for proper allowances for piping loss and pick-up-factor requirements. It has been the practice of the writer to apply a factor of from 25 to 10 per cent, as an allowance for piping load, to net load values. This is a variable factor; for, as the radiation load increases, the percentage of piping load decreases, as a general rule. For example, the piping allowance at 500 ft net load is 25 per cent gradually diminishing until at 12,000 ft, net load 10 per cent allowance should be sufficient. An additional flat allowance of 20 per cent can be considered proper for pick-up factor. This gives a total allowance for piping and pick-up of from 45 to 30 per cent, applied to net-load figures. These values are believed to be conservative and applicable to the average installation, although varying conditions may call for suitable modification of the allowances.

Finding the fuel-burning rate involves the heat value of the fuel and the overall efficiency of the boiler and burner. In an existing installation the efficiency can be checked or in some cases published data can be consulted. It is also essential that the boiler be sized to produce optimum efficiency results at the gross output required, as this is the point at which it should be operated. Published ratings and performance curves of the boiler manufacturer furnish a means of checking this point.

While these remarks are pertinent to the use of intermittently operating types of burners, an analogous situation is presented with the use of modulating types of burners. Different factors should be used for pick-up allowance, as this value is greatly reduced, if not entirely eliminated, due to the constant supply of heat to the system. However, the boiler selected should deliver its best efficiency at the output range wherein will be burned the most fuel in proportion to the total seasonal demand. This may or may not be at the range where the burner is operating most frequently, depending upon the distribution of the seasonal degree-day load.

As the author states, this optimum output range may be below the net load with the consequent use of a smaller boiler than would be selected for the same installation if intermittently fired. With the selection of a smaller boiler, care should be exercised that reasonable rates of heat liberation and heat transfer are not exceeded. These factors will be reflected in the efficiency obtained, and if the boiler is selected with due consideration as to its efficiency, it may be granted that heat-transfer values will not be excessive. In a steam or vapor system it is also essential that the amount of water contained in the boiler be sufficient to care for the condensing effect of the system.

In reference to the several phases of burner adjustment and operation noted by Professor Seeley, it may be stated that the writer has obtained similar results in laboratory research. However, there are certain characteristics peculiar to each individual boiler and burner and it does not always follow that the effects pointed out will occur in the same degree or even in the same order, with certain combinations of boilers and burners.

Professor Seeley has pointed out an arbitrary "standard" condition of 10 per cent CO_2 and 0.02 in. of water furnace draft. This would seem to be a reasonable hypothesis and should furnish a proper criterion for the adjustment of oil burners in the field.

A compilation of data obtained from 262 oil-burner installations yields the following results:

CO_2, per cent	No.	Per cent of total
10 or higher	60	22.9
8–10	72	27.5
6– 8	71	27.1
4– 6	51	19.5
Below 4	8	3.0

The draft in the combustion chamber was less than 0.02 in. of water in 80 cases or 30 per cent of the total. The draft was 0.02 to 0.05 in. in 131 cases and was more than 0.05 in. in 51 cases or 20 per cent of the total.

Professor Seeley stated that boiler design has a direct bearing upon preventing the escape of the heated gases during "off" periods of intermittent burner operation. This is particularly true of boilers having a downward flue pass or passes. Such construction impedes the natural circulation through the boiler during the "off" period with a consequent lessened cooling effect of the heat-absorbing surfaces of the boiler.

A secondary source of air due to leakage in the boiler setting is present in the majority of installations and it is highly desirable that this be reduced to a minimum. Obviously, the amount of leakage will be determined by the draft in the furnace. In general, this should not exceed 0.02 to 0.05 in. of water.

R. C. CROSS.[7]

[5] See MECHANICAL ENGINEERING, April, 1935, pp. 221–224.

[6] London, England. Mem. A.S.M.E.

[7] Supervising Engineer of Research, The H. B. Smith Co., Westfield, Mass. Jun. A.S.M.E.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Road and Rail in Forty Countries

ROAD AND RAIL IN FORTY COUNTRIES. By Paul A. Wohl and A. Albitreccia. Oxford University Press, London, 1935. Cloth, 5 × 7½ in., 455 pp., supp., tables, $6.

REVIEWED BY JULIUS H. PARMELEE[1]

THIS comprehensive survey of railway and highway transport throughout the world was conducted as an activity of the International Chamber of Commerce.

The Chamber has devoted much time and attention to the road and rail problem, which, in some countries, has grown to even more serious dimensions than in the United States. A resolution adopted by the Chamber at its Washington Congress of 1931 recommended that an inquiry be undertaken, first, to ascertain the facts as to the development of motor transport and its effect on railroad traffic, and second, to consider what modifications may be desirable in the principles underlying railroad rate schedules. In line with this recommendation, the Chamber staff in 1933 published an introductory report on road and rail transport. The present volume supplements and complements the earlier report.

Forty countries are included in the survey. Four of these countries are in the Americas, namely, the United States, Canada, Mexico, and Brazil. Twenty-three are in Europe, eight in Asia, and four in Africa, while Australia was handled as a unit.

The first part of the report is devoted to a descriptive analysis of the development of highway transport, regulation, and the relationship of railways to highways, in each of the forty countries.

The second part is an analytical study, topographical rather than geographical in arrangement. This study shows the legal bases of the organization of rail and road transport, the taxes imposed upon both, and the measures undertaken by railways to meet motor-vehicle competition.

The outstanding feature of the report is the close parallelism of transport problems the world over, and the striking similarity of the methods developed in the principal countries to bring about a closer coordination of rail and motor transportation.

A compilation of the statistics of motor vehicles scattered throughout the report produces the following comparison with the United States:

	Forty Countries	United States
Motor trucks.....	5,105,535	3,233,457
Motor buses.....	331,824	104,000
Private automobiles..	28,575,296	22,476,646
Type not reported...	34,970	.....
All motor vehicles	34,047,625	25,814,103

The United States, with one-third of the world's highway mileage, possesses more than 75 per cent of all motor vehicles, 63 per cent of the trucks, 31 per cent of the buses, and more than 78 per cent of the private automobiles. For the forty countries combined, 84 per cent of all motor vehicles are private automobiles, while 15 per cent are motor trucks; for the United States, the corresponding proportions are 87.1 and 12.5 per cent, respectively.

CONDITIONS IN FIVE COUNTRIES

The present review will digest only those sections of Part I regarding road and rail in five countries: United States, Canada, Great Britain, France, and Germany.

United States. Street and highway costs in the United States in 1930 aggregated $2,063,330,815, of which motor-vehicle users contributed $897,982,422, or 30.4 per cent.

There is no Federal regulation of truck or bus operators in the United States.

Railway passenger traffic has been more greatly affected by competition from private motor cars than from motor-bus service. In freight traffic, competition has been keenest within a radius of from fifty to two hundred miles, especially in less-than-carload traffic.

The railways have adopted three kinds of measures to meet motor-transport competition. The first is technical, involving improvements in operations, service, equipment, and the like. Second is the organization of their own motor-transport services, as substitutes for unprofitable train service, as feeder services in areas not reached by rail, or as independent services operated by the railways themselves. The third type consists of adjustments in freight and passenger rates, designed to meet motor-truck and bus rates.

Public sentiment in the United States is to the effect that nothing should be done to arrest motor-vehicle development, but that the present unrestrained competition should be replaced by more rational forms of competition between rail and highway transport.

Canada. Both of the two leading railways in Canada have suffered severe losses in passenger and freight traffic since 1928.

Highway conditions have not been favorable to the development of motor transport. Many of the roads are unimproved, while some of the improved earth roads are closed to traffic during the long winter. Motor transport is generally restricted to those sections that are most densely populated, or are better situated geographically.

There is an increasing tendency in Canada to regulate motor buses. Taxes paid by them are high. In Ontario, a thirty-passenger motor bus traveling 30,000 miles a year pays a tax of $840, while a motor truck traveling the same distance pays only $215. Motor-truck traffic has not yet seriously affected railway traffic. "In a country where the climate and great distances have a considerable influence on transport methods, it is hardly possible for the automobile to become a real danger for the railways."

Great Britain. The decline in rail traffic in recent years is explained by the economic crisis, and by development of the motor vehicle.

Motor-transport growth has been rapid in Great Britain. The capital invested in British highways is estimated as between 1,600,000,000 and 2,000,000,000 pounds. The annual expenditure for upkeep and construction of new highways aggregates 60,000,000 pounds.

The British railways have adjusted themselves to the competitive situation by modernizing their delivery systems,

[1] Director, Bureau of Railway Economics, Washington, D. C.

and by acquiring a part in many existing motor-transport undertakings. Parliament has passed several acts designed to regulate the motor-traffic situation, such as the Road Traffic Act of 1930, and the Road and Rail Traffic Act of 1933. All commercial motor-vehicle operators must now be licensed. The railways have the right to make special rates to any shipper, on approval by the Railway Rates Tribunal.

France. The railways of France consist, for the most part, of five private companies and the state system. The private companies operate under concessions from the state. They are under close supervision by the state, state directors sit on the board of each company, and their annual deficits are guaranteed by the state.

The state system is made up of the state railway proper and the Alsace-Lorraine system, which was taken over after the war.

French railways have been and are in serious financial condition. Their annual deficits have increased steadily, from 180,000,000 francs in 1929 to 4,109,000,000 francs in 1932, while their revenues have been declining.

Highway improvement in France has been rapid, and annual road expenditures approximate 5,000,000,000 francs.

Legislation respecting motor transport has favored the operator. Freight-transport enterprises have complete freedom, being subject only to the same provisions as are applicable to every motor-car owner. In addition, the state may grant subsidies to motor-transport service for the conveyance of freight. Subsidies are also granted to certain passenger motor operations, subsidized lines being subject to regulatory measures.

Motor enterprises pay the same general taxes levied on other industries, and in addition pay gasoline and oil taxes, registration taxes, a tax on drivers' licenses, and a road-maintenance tax. The total of these special taxes amounted in 1930 to 3,400,000,000 francs.

The decrease in passenger traffic on the railways is ascribed generally to motor-transport development. Motor-truck competition has been felt more especially in connection with livestock, household goods, groceries, wines, and other similar forms of traffic. The railways calculate that their loss to motor transport is 410,000,000 francs per year, of which slightly more than half was lost to passenger traffic, and slightly less than half to freight traffic.

To meet this competition, the railways have established reduced rates in certain cases, have speeded up their parcel traffic, and have increased their transport and delivery services.

Germany. Following the war, all the railways in Germany were transferred to the central government. They are operated by an organization known as the Deutsche-Reichsbahn Gesellschaft (DRG).

Railway traffic has been declining, so that in 1933 the company had a total deficit of 309,900,000 Reichsmarks. The deficit is largely due to the economic crisis, heavy fixed charges, and motor-transport competition.

Highways in Germany are constructed and maintained by the states, provinces, counties, and municipalities. For this reason, it is difficult to secure comprehensive statistics as to the costs of highways.

Motor-bus operations are conducted by the Reichspost or Post Office Department, by provincial, municipal, and other governmental authorities, and by privately organized enterprises. The most important service is that of the Reichspost.

Taxes paid by motor-carrier operations, in addition to the usual capital and income taxes and other taxes on property, include the motor-vehicle tax and the tax on fuel, which produce some 670,000,000 rm per year.

The railways have met the competitive situation by improved service, more rapid delivery, better connections, container services, and the like. Reduced rates have also been made.

The government has instituted a license system for motor-transport service, together with compulsory minimum tariffs, designed to bring motor and rail rates into a condition of greater balance.

PRINCIPAL ASPECTS OF ROAD AND RAIL PROBLEM

Part II of the report is devoted to an analysis of the principal aspects of the road and rail problem.

With the coming of motor transport, a limited or authorization system of concessions has developed, consisting of regulation and compliance with certain conditions of an administrative or technical nature, none of which applies to the railways.

The distinction usually made between different forms of motor transport are between, first, public and non-public transport; second, common carrier and contract carrier, and third, regular and occasional transport. Railway tariff regulations have been developed to a considerable degree in most countries, but the structure of motor-carrier tariffs is, as a rule, less clearly defined.

Two forms of transport taxation are described. The first is of the nature of tolls, which may be paid either by the carrier or by the user. The second may be a tax either on the physical quantity of traffic, or on the financial yield, in terms of gross or net revenue.

Motor-transport taxes in the United States are described as the Federal excise tax on gasoline and on lubricating oils, together with percentage levies on new motor vehicles, tires, and tubes. The state taxes are the usual property tax and special taxes consisting of registration or license fees and a gasoline tax. License fees for commercial vehicles are graduated to the weight of the vehicle, the number of seats, the gross receipts, the distance covered, or the output in passenger-miles or ton-miles.

Measures adopted by the railways in various countries to meet motor-transport competition are next analyzed. A long list of technical measures is presented, the more important of which are the speeding-up of trains, the establishment of door-to-door delivery, utilization of containers, establishment of joint services with motor-transport agencies, and organization of motor services by the railways themselves.

Many tariff measures have also been adopted, consisting generally of reduction of rates, introduction of a flat rate for small consignments, reduced tariffs for consolidated consignments, special door-to-door rates, establishment of joint road and rail tariffs, and special tariffs for passengers traveling with motor cars.

The survey of general legislation designed to regulate motor transport describes certain regulations as to safety, hours of work, wages, insurance, and the like.

Three comprehensive tables or charts are inserted at the back of the volume which give a bird's-eye view of the situation in the different countries. The first table outlines the legal bases of railway and motor-transport organization in the several countries. The second table indicates the types of taxation levied on both railway and motor transport in the various jurisdictions. The third table lists the various measures taken by the railways to meet motor-transport competition. There are 20 items under technical and other measures, together with many sub-items, and 17 items under tariff measures, with a number of sub-items as well. This indicates that the railways have not been idle in designing and in instituting measures with which to meet the inroads of the motor vehicle.

Statistics

TREND ANALYSIS OF STATISTICS, THEORY, AND TECHNIQUE, by Max Sasuly. The Brookings Institution, Washington, D. C., 1934. Cloth, $6^1/_2 \times 9^1/_2$ in., 421 pp., $5.

MATHEMATICS ESSENTIAL FOR ELEMENTARY STATISTICS, by H. M. Walker. Henry Holt and Company, New York, N. Y., 1934. Cloth, $5^1/_4 \times 7^1/_2$, 246 pp., $1.50.

REVIEWED BY E. DILLON SMITH[2]

THIS first of these books is of particular interest to the engineer since precise trend determination is important in many branches of engineering and the allied sciences. The basis of and the technique for trend analysis in some of its most recent forms are discussed. The book is arranged so that the theoretical presentation is often followed by an illustrated example. The methodology presented will be found to be time-saving and effective for any research laboratory or office.

The usual form of the polynomial

$$u_x = a_0 + a_1 x + \ldots + a_q x^q \ldots [1]$$

Polynomials like [1] have many drawbacks; some of which are: difficulty of fitting to data; loss of original work when degree of fit is altered after the original fit; correlation between terms; and complicated tests of significance of the various terms.

These drawbacks can be eliminated by the use of orthogonal polynomials. This book is mainly concerned with the orthogonal series

$$u_x = K_0 + K_1 T_1(x) + K_2 T_2(x) + \ldots + K_q T_q(x) \ldots [2]$$

which is subject to the orthogonality property

$$\Sigma T_j T_q = 0; \quad j \neq q \ldots [3]$$

The property of [3] means that there is no correlation between successive terms of [2] as is the case of [1]. An effective technique to simplify the numerical computation of fitting [2] to data by use of a tape- or listing-adding machine and a mechanical computator is also presented. The fitting process is carried out in successive stages.

A discussion of interpolation and power and factorial moments are among some of the specialized subjects that have also been presented in connection with the analytic trend determinatior of polynomials. Several fitting criteria are suggested, while special attention is given to the criterion of least squares.

Books of this type and usefulness are, indeed, rare. Its theories and techniques are suitable for the analysis of many problems in engineering. This book is, in fact, one of the best that has been published in this country that has come to the reviewer's attention for some time. Unfortunately, some of the simpler European techniques, such as those of Aitken and Fisher, have not been mentioned by the author; probably due to their publication after Sasuly's manuscript was complete.

Most of the engineers and technical men are now discovering that in order to understand the modern world, and in order to read the rapidly expanding literature of their fields, they need to become conversant with statistical method. But statistical method, even in its simpler phases, is a branch of applied mathematics. Refusal to admit this fact will not lessen the difficulties which await the technical man who is unable to think competently in numerical and symbolic form. Dr. Walker's book contains all the mathematical topics which contribute most directly to elementary statistical method, with the exception of calculus.

This book presupposes only a slight knowledge of mathematics, but, on the other hand, it does not deal at length with simple and elementary relations and a great deal of the material in this book is probably unfamiliar to the engineer. Stress is laid on the principle of summation and the ability to use symbolism creatively as a language; on the development of such concepts as "variable," "parameter," and "residual;" on homogeneity among moments and the method of least squares; and on the derivation of a number of simple statistical formulas. The arrangement of the book permits a rapid review of those topics with which the engineer has once been familiar, and enables him to omit those topics he has already mastered, and to discover quickly those sections containing material he does not know. This, alone, is a good recommendation for the book. The book is not a statistical text, as its subject indicates.

Dr. Walker has done a fine job, and the book should be in the hands of those who want to know about the mathematics essential to the statistical method who but do not have the necessary background. It will aid those interested in the subject, for too few researchers and industrialists have a clear idea of the basic foundation upon which statistical method is built.

[2] Chairman, A.S.M.E. Committee on Statistics in Industry. Department of Mechanical Engineering, School of Technology, The College of the City of New York, New York.

Books Received in Library

AIR CONDITIONING, Fundamental Principles, Practical Installations, and Ozone Facts. By E. W. Riesbeck. Goodheart-Willcox Company, Inc., Chicago, 1934. Leather, 5 × 8 in., 352 pp., illus., diagrams, charts, tables, $3.50. The first section of this book discusses the installation and operation of air-conditioning equipment in non-technical language and from a practical point of view. The second section discusses in similar fashion the use of ozone for sterilizing air and water. The book is designed to assist heating and plumbing contractors and others interested in air-conditioning.

A.T.M.—Archiv für Technisches Messen. Tables 39–44, September, 1934—Feb., 1935. R. Oldenbourg, Munich. Paper, 8 × 12 in., illus., diagrams, charts, tables, 1.50 rm. each. This interesting review of methods and instruments for use in technical measurements covers a wide field. The book appears serially. Each article is classified and arranged so that the material can be collected in loose-leaf binders. The articles are by specialists and are provided with useful bibliographies, making the work a useful reference tool.

BIBLIOGRAPHY OF AERONAUTICS, 1931. National Advisory Committee for Aeronautics. Government Printing Office, Washington, D. C., 1935. Paper, 7 × 10 in., 312 pp., $0.50. This bibliography continues the series begun by the Smithsonian Institution in 1909 and continued since then by the National Advisory Committee on Aeronautics. The present volume presents an author and subject index to the publications of 1931, including books, the contents of forty-six magazines, and the publications of Government departments, research institutions, etc.

BOILER FUELS AND TRIALS. By A: S. Callen and I. C. S. staff. International Textbook Co., Scranton, Pa., 1933. Leather, 5 × 8 in., diagrams, tables, $1. The first section of this book discusses the composition and characteristics of coal and fuel oil, their analysis and proper methods of burning them. The second section describes the conduct of boiler trials and the calculation of the results. The presentation is simple and practical.

DAVISON'S RAYON AND SILK TRADES. Fortieth edition. Davison Publishing Co., New York, 1935. Cloth, 5 × 7 in., 587 pp., maps, $5.50. A guide and directory to the silk and rayon industry of America. Manufacturers, dyers, wholesalers and jobbers of these textiles are included, as well as makers of machinery, supply houses, etc. The book attempts to meet all the needs of sales and purchasing departments and is revised annually.

ELEMENTARY MECHANICS. Revised edition. By J. B. Reynolds. Prentice-Hall, New York, 1934. Cloth, 6 × 9, 336 pp., diagrams, $2.75. This text is intended for a first course in mechanics in technical schools and for a course in institutions which desire to prepare students for technical work with the least possible groundwork in mechanics. The book calls for only an elementary knowledge of algebra and geometry, and is confined to the easier applications of the subject. Extensive use is made of illustrative examples, and many problems and exercises for the student are included.

ELEMENTS OF MOTOR VEHICLE DESIGN. By C. T. B. Donkin. Second edition. Hum-

phrey Milford, London; Oxford University Press, New York, 1935. Cloth, 6 × 9 in., 289 pp., diagrams, tables, $4.25. This text presents the basic principles of automobile design and shows how they are applied in practice. Working formulas are given and their use shown by worked examples. The book is designed as a textbook for students and a reference work for designers and draftsmen. The new edition has been revised and partly rewritten.

FENCING AND OTHER SAFETY PRECAUTIONS FOR POWER PRESSES. Safety Pamphlet No. 9. His Majesty's Stationery Office, London, 1934. Paper, 6 × 10 in., 86 pp., illus., diagrams, 1s 6d. (British Library of Information, New York, $0.50.) The dangers attendant upon the operation of presses for working sheet metal are indicated and methods for preventing them are shown in this pamphlet. A large number of guards and safety devices are illustrated and proper methods of work are explained.

FORSCHUNGSHEFT 370. STRÖMUNGSMASCHINEN zum Ahnlichkeitsgesetz für Hohlraumbildungen, by A. Reinhardt; Strömung in Spiralgehäusen, by H. Kranz. V.D.I. Verlag, Berlin, January–February, 1935. Paper, 8 × 12 in., 31 pp., illus., diagrams, charts, tables, 5 rm. In the first of these researches upon hydraulic turbines Dr. Reinhardt discusses the application of the theory of similitude to the problem of cavitation. Previous work has been collected and extended, and the deductions tested by experiments to determine their practical applicability. Experimental results deviated from the Newtonian law of similitude. In the second paper Dr. Kranz reports an investigation of the flow in turbine spirals of various forms, and the effect of the shape of the housing upon turbine efficiency.

FÜHRER DURCH DIE TECHNISCHE MECHANIK, Eine neuartige Übersicht über ihre Grundlagen Methoden und Ergebnisse für Studium und Praxis. By H. Müller. J. Springer, Berlin, 1935. Paper, 7 × 10 in., 118 pp., diagrams, charts, tables, 8.50 rm. The aim of this book is to present the principles, methods, and results of technical mechanics in a way that will bring out clearly the inter-relations of statics, kinetics, and kinematics as branches of a single science. The work is comprehensive and concise, and well suited for those wishing to review the subject or in search of a convenient reference book.

HANDBOOK OF BUTANE-PROPANE GASES. Edited by G. H. Finley. Second edition. Western Gas, Los Angeles, Cal. Leather, 9 × 12 in., 375 pp., illus., charts, diagrams, tables, $5. The handbook provides a comprehensive survey of the growing liquefied petroleum-gas industry, prepared by a number of specialists. The physical and chemical properties of these gases; methods of testing and analysis; their manufacture from natural gas and extraction from refinery gases; transportation, storage, distribution, and uses are all discussed. A large amount of practical information is brought together in convenient form. There is an extensive bibliography, covering the literature from 1926 to 1934.

HANDBUCH DER METALLPHYSIK. Edited by G. Masing. Vol. 1, DER METALLISCHE ZUSTAND DER MATERIE. Part 1: Gitteraufbau metallischer Systeme. By U. Dehlinger. Part 2: Grundlagen des metallischen Zustandes. Physikalische Eigenschaften der Metalle. By G. Borelius. Akademische Verlagsgesellschaft, Leipzig, 1935. Cloth, 7 × 10 in., 520 pp., diagrams, charts, tables, 47.60 rm. This is the first volume of four which are to be issued under the editorship of the director of the electrochemical laboratories of the Siemens & Halske Company, and which are intended to survey the results that have been obtained by the application of physical methods to the study of the science of metals. In the present volume, Professor Dehlinger discusses the lattice structure of metallic systems, and Professor Borelius the fundamentals of the metallic state and the physical properties of metals. The book affords a convenient, authoritative review of these subjects. Extensive bibliographies are provided.

HENLEY'S TWENTIETH CENTURY BOOK OF FORMULAS, PROCESSES AND TRADE SECRETS. Edited by G. D. Hiscox and T. O. Sloane. Norman W. Henley Publishing Co., New York, 1935. Cloth, 6 × 9 in., 809 pp., tables, $4. A valuable reference book for the home, factory, office, laboratory, and workshop which has been popular for over twenty-five years and has frequently been revised. This edition claims thorough revision and the addition of considerable new material.

HISTORY OF MAGIC AND EXPERIMENTAL SCIENCE. Vols. 3 and 4, Fourteenth and Fifteenth Centuries. By Lynn Thorndike. Columbia University Press, New York, 1934. Cloth, 6 × 9 in., vol. 3, 827 pp., vol. 4, 767 pp., tables, $10 (2 vols.). These volumes extend Professor Thorndike's important study of medieval thought on scientific matter through the fourteenth and fifteenth centuries, and provides welcome assistance to the student of the history of experimental science, who will find them indispensable. Much of the work is based upon manuscripts that have been unexamined heretofore, and many new experimenters and inventors have been discovered. The work is issued by the History of Science Society.

HERSTELLUNG UND EIGENSCHAFTEN DER KUNSTSEIDE UND STAPELFASER. (Ergebnisse der angewandten physikalischen Chemie.) Vol. 2. Edited by M. Le Blanc. By A. Zart. Akademische Verlagsgesellschaft, Leipzig, 1935. Paper, 6 × 9 in., pp. 229–346, illus., diagrams, charts, tables, 9.80 rm. This little book forms part of a larger work, the "Results of Applied Physical Chemistry." It presents, in compact form, a summary of the theoretical principles underlying the various processes used for manufacturing rayon. The book affords an excellent review of the subject in concise form and contains an extensive bibliography.

JONES' ESTIMATING TABLES on Air Requirements and Duct Sizes for Heating and Air Conditioning. Domestic Engineering Publications, Chicago, 1934. Cloth, 6 × 9 in., 68 pp., diagrams, tables, $2.50 (subscription to *Domestic Engineering* included). These tables present a rapid method for estimating heating and air-conditioning installations for dwellings, intended for use of contractors. The tables enable the air requirements, duct sizes, etc., to be determined for any forced-air heating system, under winter conditions in any part of the United States.

JOURNAL OF THE ROYAL TECHNICAL COLLEGE. Vol. 3, Part 3, Jan., 1935, pp. 339–526. Royal Technical College, Glasgow, Paper 7 × 10 in., illus., diagrams, charts, tables, 10s 6d. The journal records research work recently carried out by the faculty and students of the college. Among the papers of direct engineering interest are "The overstraining of mild steel, direct and bending stresses in thin spherical shells; lubrication and bearing design; the deflection characteristics of bolted joints; contact film resistance in rail-wheel force fits; the interpretation of some torsiograph records; the effect of air on heat transmission in surface condensers and air coolers; modifications of the cold-cathode Braun tube; stroboscopic examination of transitory torques; experiments on inert dust used in coal mines; the bactericidal action of ultra-violet light."

LOHSE, TAFELN FÜR NUMERISCHES RECHNEN MIT MASCHINEN. Second edition. Edited by P. V. Neugebauer. Wilhelm Engelmann, Leipzig, 1935. Cloth, 7 × 10 in., 113 pp., tables, 6 rm. The first edition of these tables appeared in 1909. The present edition is a photographic reprint in slightly smaller size, with a few omissions and some improvements. The volume includes a table of reciprocals, a table of natural trigonometric functions to five decimal places, for each one-hundredth of a degree of the quadrant, a table of square roots, and tables for converting minutes of time into degrees, and minutes and seconds of arcs into decimals. The book is clearly printed and inexpensive.

MASCHINEN UND WERKZEUGE DES GESENKSCHMIEDENS. By H. C. Braun and H. Kaessberg. V.D.I. Verlag, Berlin, 1935. Paper, 6 × 8 in., 32 pp., illus., diagrams, 1.90 rm. This little book contains a concise, well-illustrated description of modern tools and machines for die forging. The demands placed upon tools, the materials worked, tool manufacture and tool costs are discussed. The text appeared previously in *Maschinenbau*.

MARKETING INDUSTRIAL EQUIPMENT. By B. Lester. McGraw-Hill Book Co., New York and London, 1935. Cloth, 6 × 9 in., 307 pp., charts, diagrams, maps, tables, $3.50. This book presents an outline for a study of the distribution of capital goods of an engineering nature from the manufacturer to the ultimate user, based upon a course of lectures given by the author in the graduate school of the University of Pittsburgh. Methods of market and product analysis, the principles involved in economic distribution, and the organization and operation of sales departments and sales outlets are discussed.

MECHANICS OF MATERIALS. By S. G. George and E. W. Rettger. McGraw-Hill Book Co., New York and London, 1935. Cloth 6 × 9 in., 483 pp., illus., diagrams, charts, tables, $3.75. A textbook covering the essential topics of a first course in this subject, intended for students of engineering in American universities. The treatment aims to be simple and complete, and numerous complete examples are introduced to illustrate the application of theory. In discussing the design of members, modern methods of analysis and treatment are used. A chapter is devoted to the slope-deflection and moment area methods, and the theorem of three moments.

MECHANIZATION IN INDUSTRY. By H. Jerome. National Bureau of Economic Research, New York, 1934. Cloth, 6 × 9 in., 484 pp., charts, tables, $3.50. Dr. Jerome has made an extended study, largely through field sur-

veys in selected industries, of the development of mechanization in America and upon the effects observed. The nature and the results of progressive mechanization, and its social and economic consequences are discussed at length, and much detail as to actual changes is presented. The book will be of interest to students of social and economic problems generally, and especially to production engineers and factory managers.

MITTEILUNGEN AUS DEN FORSCHUNGSANSTALTEN GHH-KONZERN. Vol. 3, no. 8, April, 1935. V.D.I. Verlag, Berlin. Paper, 8 × 12 in., pp. 199–222, illus., diagrams, charts, tables, 2.70 rm. The first of these papers describes tests upon a heat-treated rail steel containing about 1 per cent of copper. The second describes a new electric cable invented by the Osnabrück Copper and Wire Works, which is highly resistant to acid, alkalis, and other chemicals. The third gives the results of an extended investigation of the form in which phosphorous occurs in chilled cast-iron rolls.

NITROGEN SYSTEM OF COMPOUNDS. (American Chemical Society Monograph Series No. 68.) By E. C. Franklin. Reinhold Publishing Corporation, New York, 1935. Cloth, 6 × 9 in., 339 pp., diagrams, tables, $7.50. All nitrogen compounds except the fluoride and the oxides may be regarded as derivatives of ammonia and as such said to constitute an ammonia system or, as these authors prefer to speak of it, a nitrogen system. The object of this monograph is to outline this system and call attention to the remarkable extent to which the compounds of nitrogen simulate in their properties and behavior the analogous compounds of oxygen.

PRAKTISCHE GETRIEBETECHNIK. By C. Breuer. No. 1: FÜHRUNGSGETRIEBE. V.D.I. Verlag, Berlin, 1935. Paper, 8 × 12 in., 29 pp., illus., diagrams, charts, 3.50 rm. This pamphlet is intended for designers of folding and wrapping machinery, and purports to be the first discussion of the principles underlying machines of this type. It describes methods for producing a wide variety of complicated foldings from a small number of simple processes. The work is the first section of a new work on gear design, which is intended to present the results obtained by research work directed by Dr. Rauh, in a form suited for practical use.

PRAKTISCHES HANDBUCH DER GESAMTEN SCHWEISSTECHNIK. By P. Schimpke and H. A. Horn. Vol. 2. Second edition. Elektrische Schweisstechnik. J. Springer, Berlin, 1935. Leather, 6 × 9 in., 274 pp., illus., diagrams, charts, tables, 15 rm. A comprehensive account of welding technique, covering arc, resistance, and gas-electric welding, electric soldering and cutting, weld testing, etc., as well as the applications of the processes for various purposes. The authors are experienced instructors, and the book is an unusually complete and detailed text, covering both theory and practice.

PRINCIPLES OF PHASE DIAGRAMS. Alloys of Iron Research, Monograph Series. By J. S. Marsh, with a foreword by J. Johnston. Published for the Engineering Foundation by the McGraw-Hill Book Co., New York and London, 1935. Cloth, 6 × 9 in., 193 pp., diagrams, charts, tables, $3. Chemists and metallurgists will find in this book a clear, concise presentation of the principles of phase theory, designed especially to facilitate clear understanding of ternary phase diagrams. The book is admirably planned to prepare the reader to interpret the phase diagrams which he meets in his reading, and to work out special cases. Users of the Alloys of Iron Research Monographs will find it very valuable as a key to the diagrams which these works contain.

PRINCIPLES OF QUANTUM MECHANICS. By P. A. M. Dirac. Second edition. Clarendon Press, Oxford; Oxford University Press, New York, 1935. Cloth, 6 × 10 in., 300 pp., tables, $6. The first edition of this book appeared in 1930 and at once won recognition as a contribution of outstanding importance to modern physical theory. The new edition has been largely rewritten and thoroughly revised. Dr. Dirac has tried to give the development of the theory in a rather less abstract form, which will be suitable for a wider circle of readers. He has also added some new matter, including a chapter on field theory.

PROCEEDINGS OF THE FOURTH INTERNATIONAL CONGRESS FOR APPLIED MECHANICS, Cambridge, England, July 3–9, 1934. University Press, Cambridge, England, 1935. Cloth, 7 × 11 in., 283 pp., illus., diagrams, charts, tables, £1. This volume contains the seven general lectures delivered at the Congress, and abstracts of the papers presented at the sectional meetings. The lectures are: Recent Progress in Analyzing Machines, by Vannevar Bush; Définition du Domaine Élastique dans le Corps Isotropes, by A. Caquot; The Vibration Problem in Engineering, by J. P. den Hartog; Some Aspects of the Turbulence Problem, by Th. von Kármán; Waermeuebertragung, by Ernst Schmidt; The Strength of Crystals of Pure Metals and of Rock Salt, by G. I. Taylor; and Ueber das Gleiten von Koerpern auf der Wasseroberflaeche, by Herbert Wagner.

PUBLIC UTILITY VALUATION FOR PURPOSES OF RATE CONTROL. By J. Bauer and N. Gold. Macmillan Co., New York, 1934. Cloth, 6 × 9 in., 477 pp., $3.50. The aim of this book is to present, in a single volume of moderate size, a comprehensive discussion of utility valuation. The economic and legal fundamentals, the practical methods pursued, and the procedural aspects of valuation are discussed, with special regard to objectives, policy, and administrative requirements of public control. The present system of rate regulation is examined critically and suggestions for revision offered. The authors are well-known specialists in the field, and the book is an important addition to the literature.

SIX WAYS TO FIGURE RADIATION. Edited by H. L. Alt. Domestic Engineering Co., Chicago, 1935. Cloth, 4 × 7 in., 64 pp., diagrams, tables, $2. The various methods which are in use for determining the amount of radiation required to heat a room are bought together in this little book, and their use explained.

STOFFERSPARNIS IN DER WERKSTATT. Drei Vorträge der Betriebswissenschaftlichen Tagung der A.D.B. vom 24, u. 25. September, 1934, in Berlin. V.D.I. Verlag, 1935. Paper, 6 × 8 in., 34 pp., maps, illus., diagrams, tables, $1.90 rm. Shortage of raw materials is a pressing problem in the German manufacturing industry, and the three addresses published in this booklet discuss certain aspects of the problem. The first describes the raw-materials situation in Germany. The second discusses possibilities of economy through suitable selection of manufacturing processes, and the third, ways in which material may be saved in machine-tool construction.

STRUCTURE AND PROPERTIES OF MATTER. By H. T. Briscoe. McGraw-Hill Book Co., New York and London, 1935. Cloth, 5 × 8 in., 420 pp., illus., diagrams, charts, tables, $3.55. This book aims to provide a concise account of some of the facts and opinions concerning matter as they have been discovered or suggested from the time of Aristotle to that of Bohr and Schroedinger, and to interpret them from the point of view of the chemist. It provides an elementary description of the physical and mathematical concepts of matter in a single volume, adapted for class study, and suited to the needs of older students who wish to bring their information up to date.

TEXTBOOK OF MECHANICAL ENGINEERING. His Majesty's Stationery Office, London, 1934. Cloth, 6 × 9 in., 690 pp., illus., diagrams, charts, tables, 12s. This manual of engineering practice is issued by the British War Office, for use of army engineers and mechanical workmen. Part one, on workshop practice, describes foundry work, blacksmithing, boilermaking, welding, fitting, metal and woodworking. Part two, on heat engines, describes the maintenance and operation of steam, gas, and oil engines. Part three describes the transmission of power, lubrication, and the operation of air compressors and pneumatic tools and of refrigerating machinery. The treatment is entirely practical, and a large amount of definite information is compressed into a single volume.

THEORY OF VIBRATIONS FOR ENGINEERS. By E. B. Cole, Crosby Lockwood & Son, London, 1935. Cloth, 5 × 9 in., 263 pp., diagrams, charts, tables, 15s. This book aims to bridge the gap between the elementary treatment of this subject which is found in textbooks on the elasticity of materials and the higher studies which call for considerable mathematical attainments. It provides an intermediate course, in which the physical meaning of the mathematical equations is stressed and special attention is given to methods of practical utility to designers of high-speed machinery. There is a brief bibliography.

THOMAS' REGISTER OF AMERICAN MANUFACTURERS. Twenty-fifth edition. Thomas Publishing Co., New York, 1935. Cloth, 9 × 12 in., 10,914 columns, illus., $15 (to advertisers and renewal subscriptions $10). This volume provides a directory of manufacturers, a directory of manufactured products with the names of the makers, and a directory of trade names. In addition there are directories of banks, commercial institutions, and trade papers. The book is the most comprehensive directory of the kind. The present edition has been thoroughly revised and considerably enlarged.

TOOLS OF TOMORROW. By J. N. Leonard. Viking Press, New York, 1935. Cloth, 6 × 9 in., 310 pp., illus., $3. Mr. Leonard discusses modern developments in power resources and power distribution, in the creation of new alloys, in automatic machinery, and in transportation and communication, and discusses some of the ways in which these might make life easier, less laborious, and more secure. He also points to some lines along which striking progress may be expected. It is a thoughtful, interesting account of technological possibilities for the layman.

WHAT'S GOING ON

This Month's Authors

EXTRAORDINARY activity and interest in hydroelectric developments call for a review of the factors involved in comparing steam and hydro power plants. The article by E. M. GILBERT in this issue is taken from a more extensive paper on the subject recently presented. Mr. Gilbert, who is a member of the A.S.M.E., is a graduate of Cornell University. He has been closely associated with steam and hydro plants since 1907. He served two years with Bonbright and Company, reporting on various public-utility properties. Later he was vice-president and chief engineer of the W. S. Barstow Management Association, Inc. At present he is president of the E. M. Gilbert Engineering Corporation, of Reading, Pa.

TH. VON KÁRMÁN, member, A.S.M.E., and director, Guggenheim Aeronautics Laboratory, California Institute of Technology, Pasadena, Calif. He was educated abroad and holds degrees from Budapest, Göttingen, and Berlin. Before coming to this country he was engaged at Göttingen and at the University of Aachen.

Since 1884 AUGUSTUS H. GILL has been connected with the department of chemistry at the Massachusetts Institute of Technology. He styles himself a "reactive" chemist, and defines reactive as "the term applied to a person retired by rule, but still capable of action—hence in a chemical sense reactive."

From a more extensive manuscript which contained detailed information on the lubricants in use at the Inland Steel Company, the paper by B. S. BURRELL was prepared. Mr. Burrell is highly regarded for his knowledge and ability in the mechanical departments of the steel industry. For 22 years he has been in direct charge of mechanical repair, maintenance, and lubrication at the Inland Steel Company, Indiana Harbor, Ind., where he serves as general master mechanic.

Every engineer knows who HERMAN SCHNEIDER, president of the University of Cincinnati, is and what he has done for engineering education in developing the "co-operative system." A chorus of loud amens will greet the reading of the last sentence of his paper.

The legal status of the Committee on Apprenticeship Training of which WILLIAM F. PATTERSON is a member was apparently brought into question by the famous poultry decision of the Supreme Court. However, the work of training apprentices is not open to serious question, and Mr. Patterson's long experience in vocational guidance and education, chiefly in Wisconsin where so much pioneering in apprentice training has been carried on, entitles him to speak with authority on this subject.

J. F. KOLB, who is now dirctor of the department of industrial relations of the National Metal Trades Association, has a background of educational experience as state supervisor of industrial education for Illinois and as director of vocational education for the Board of Education of Salt Lake City.

The study on the effect on the metal of various methods of cutting, including particularly flame cutting by means of hand and machine operated torches, was made by J. H. ZIMMERMAN, member, A.S.M.E., and assistant professor of mechanical engineering, specialist in the materials of engineering.

R. G. MCELWEE, general manager of the Ecorse Foundry Company, Ecorse, Detroit, Michigan, following a long experience in foundry work and the purchase of castings, has specialized in a foundry business to serve industries that have unusual metallurgical requirements and limited foundry facilities.

When questions of new engineering societies and coordination of existing ones come up, HUBER O. CROFT, head of the department of mechanical engineering, University of Iowa, Iowa City, Iowa, and member, A.S.M.E., looks at the facts, makes a comprehensive study of the organizations that already exist, and develops a plan for a single unified engineering society—presented in this issue.

This month's contribution from the department of economics, M.I.T., on current economic literature of interest to engineers, is by HAROLD A. FREEMAN, of that department.

Boards of Founder Societies Meet With Their Joint Functional Organizations

PROGRESS in a better coordinated engineering profession was made on May 20 when board members of the Founder Societies and representatives of the numerous joint functional organizations in which these societies have common interests and obligations met for dinner at the Engineers' Club, New York. In addition to the civil, mining, mechanical, and electrical national societies, there were represented the United Engineering Trustees, Inc., holding corporation and administrator of the joint real-estate and financial affairs of the Founder Societies; its two departments, the Engineering Societies Library and the Engineering Foundation, an institution for the furtherance of research in science and engineering; the American Standards Association; the Division of Engineering and Industrial Research of the National Research Council; the Engineering Societies Employment Service; the American Engineering Council; and the Engineers' Council for Professional Development.

The dinner provided the double opportunity for the board members and representatives to become acquainted with one another and to learn about the activities of the joint functional organizations. Graphic exhibits, presenting essential facts on the work of each organization, had been prepared and were on display before and after the dinner. Arthur S. Tuttle, president, A.S.C.E., presided, and Harvey N. Davis, president, Stevens Institute of Technology, acted as toastmaster. About 90 were present. The American Society of Mechanical Engineers was represented by President Flanders, Past-President Wright, every member of the Executive Committee, Secretary C. E. Davies, and members of the Staff.

UNITED ENGINEERING TRUSTEES, INC.

Reporting for the United Engineering Trustees, Inc., its president, Harold V. Coes, member, A.S.M.E., gave the market value of its securities as $1,236,677.25, with a book value of $1,338,852.98. During the year the by-laws had been revised, he said, and needed improvements had been made to the Engineering Societies Building.

ENGINEERING SOCIETIES LIBRARY

For the Engineering Societies Library, Walter I. Slichter, chairman, claimed the distinction of its being the largest maintained by any professional organization. Its collections included 145,000 volumes, he said, and it was used by 41,000 persons in 1934. Engineers in 45 states and 21 foreign countries were helped by loans of books, copies of translations, or by direction to the literature. One-fourth of those who consulted the library did so by correspondence. As to finances, he reported that operating costs in 1934 had been $48,500, of which the Founder Societies had contributed $30,000, or 60 cents per member. $8500 had been earned by special services, he said, and the remainder had come from endowment. The appraised value, he announced, was $500,000.

Turning his attention to plans for the future, Mr. Slichter said that it was the Board's desire to enlarge its usefulness to distant members, and outlined two plans to accomplish it.

"The first, which is in process of being put into effect, is to encourage and assist the public libraries in the various towns and cities to provide better facilities for the engineers of the neighborhood. This will be accomplished by making up a list of highly useful and desirable books and arranging that every librarian gets a copy, and incidentally to encourage the individual librarians to call upon us for help, advice, and suggestions in building up their engineering sections.

"The second proposal is to build up a more ambitious auxiliary lending library of the

books most useful and generally in demand, and lend these on request by mail. This will require capital for the purchase of the books and operating expense to administer the system for the best interests of all concerned. It is a plan which we hope to put into execution as soon as financial conditions make it possible."

ENGINEERING FOUNDATION

H. P. Charlesworth, chairman of the Engineering Foundation, spoke briefly of the gifts by Ambrose Swasey, past-president and honorary member, A.S.M.E., by which that organization had been set up and financed, and of its objectives, powers and policies, resources, functions, and methods. He listed some of its activities in the fields of education and sociology, and some of the technical researches that had been assisted by its funds.

AMERICAN STANDARDS ASSOCIATION

As vice-president of the American Standards Association, Frederick E. Moskovics read a statement on the work that had been prepared by Howard Coonley, member, A.S.M.E., president of A.S.A., who was unable to present it in person. He said that more than 3000 technologists and experts were now at work on more than 200 standardization and safety-code projects. Receiving its first great impetus during the World War, the standardization movement in this country, he pointed out, was subsequently reorganized to serve industry. Starting as it did in machine shops with screw-thread standards, fits, and industrial safety codes, it outgrew the narrower confines of the shops and spread into every major manufacturing industry and into the homes of consumers. The A.S.A., he said, was the central clearing house for American standards and safety codes. In spite of two reorganizations since the A.S.A. was formed, no reason had been found to change its fundamental functions. Many states had written A.S.A. Codes into their regulatory provisions, he remarked.

"As long as industry has the machinery to adjudicate its own problems," he concluded, "we can resist inroads contemplated by government. The machinery of the A.S.A. has been tested for a long time, and it works. Today we are gearing it to an accelerated pace, to perform the duties and obligations which will be imposed upon us tomorrow by manufacturers, distributers, and consumers."

NATIONAL RESEARCH COUNCIL

The work of the Division of Engineering and Industrial Research, National Research Council, was presented by Maurice Holland, its director, who read a statement by Charles F. Kettering, member, A.S.M.E., entitled "Industrial Prospecting;" and by D. S. Jacobus, past-president, A.S.M.E.

"In its primary functions," said Dr. Jacobus, "the Division of Engineering and Industrial Research attempts to maintain a balance between: (1) The demonstration of research methods and techniques through large, national research projects representative of the major fields of engineering. Projects selected are broad and fundamental in character, of importance to groups of industries or one or more branches of engineering. (2) The promotion of research in the field of industry, largely through trade associations by such methods as addresses, literature, meetings, conferences, radio talks, research-laboratory inspection tours. (3) A research information service.

The Division of Engineering and Industrial Research, he went on to say, cooperates with Engineering Foundation, which furnishes it office space in the Engineering Societies Building. The Division is in touch with 1600 industrial-research laboratories in this country, and in correspondence with 100 laboratories in the principal research centers abroad. It depends on interested industry for support of specific research projects.

Dr. Jacobus then reviewed briefly the work of the Division and its policies and committee organization procedure. He discussed the promotion of industrial research, and cited two special projects of the Division that demonstrated its strategic position in organizing and mobilizing scientists and engineers for national and international events: the World Engineering Congress, held in Japan in 1929–1930, and the Chicago Century of Progress Exposition. He described the Division's research information services, its administration of grants in aid in research, and its cooperation with the Science Advisory Board.

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

George T. Seabury, secretary, A.S.C.E., and chairman, National Committee, Engineering Societies Employment Service, reviewed briefly the development of the Service since 1918, with its three offices in New York, Chicago, and San Francisco. In normal times, said Mr. Seabury, the Employment Service was self-supporting, and in good times a surplus had been built up. During the past five years, however, this surplus had been exhausted and the major cost of operating the three offices had been borne by the Founder Societies. Reporting on the effectiveness of the Service, Mr. Seabury said that from 1923 to 1934, inclusive, 33,372 engineers had been registered in the three offices, 28,721 positions had been received for filling, and 13,870 placements had been made. Twenty-five per cent of the combined memberships of the Founder Societies had been assisted on one or more occasions. In view of the extent to which the Service had served members, he contended, this activity should be continued, improved, and expanded.

AMERICAN ENGINEERING COUNCIL

At present the American Engineering Council's membership is made up of 7 national, 9 state, and 25 local engineering societies, said John F. Coleman, president of the Council. Through these societies about 60,000 of their members are represented by the Council, which has been called the Washington Embassy of American engineers and engineering. Mr. Coleman spoke of the renewed interest in the Council being shown by state and local societies as a result of establishing more reasonable fees, of the manner in which the Council functions through committees, of certain objectives before the Council, and of its belief that there is an opportunity and need to advance the engineering profession by promoting the purposes of functional organizations and establishing coordinated committees between existing agencies, rather than starting new societies.

ENGINEER'S COUNCIL FOR PROFESSIONAL DEVELOPMENT

The purpose of the Engineers' Council for Professional Development, said C. F. Hirshfeld, member, A.S.M.E., its chairman, is the enhancement of the professional status of the engineer. It aims to coordinate and promote aspirations and efforts directed toward higher standards of education and practice, greater solidarity of the profession, and greater effectiveness in dealing with technical, social, and economic problems. The Council is a joint body, he continued, because the purposes for which it was formed could not conceivably be achieved except through the most intense and sympathetic cooperation of national organizations representing several different interests in the profession. It consists of 21 members, three appointed from each of seven participating bodies. Of these the Founder Societies (A.S.C.E., A.I.M.E., A.S.M.E., and A.I.E.E.) and the American Institute of Chemical Engineers represent the major branches of the practice of engineering. The Society for the Promotion of Engineering Education obviously represents educational interests, while the National Council of State Boards of Engineering Examiners, a national organization formed by members of the boards set up by the different states for the registration of engineers, is obviously a necessary participant, since it represents the increasingly important legal aspect and responsibility of the profession.

Mr. Hirshfeld continued to discuss the objectives and functions of the Council and its program, and to describe the work of its four subcommittees on (1) Student Selection and Guidance, (2) Engineering Schools, (3) Professional Training, and (4) Professional Recognition. He then spoke of the engineer's failure to take proper cognizance of the economic and social results of his work, and concluded by saying:

"The program of E.C.P.D. therefore visualizes the production of an engineer of much greater breadth of vision than has been customary in the past. It stands for the soundest sort of training in technical matters but aims at the same time to develop that broad appreciation of human problems that it feels is necessary in the engineer of the future. By such a route it sees the engineer growing to full professional status and to full recognition as a professional man."

GENERAL DISCUSSION

Following the presentation of the reports, discussion was heard from the floor. Among those who spoke were President Flanders, Past-President Roy V. Wright, Charles F. Scott, and W. L. Batt, members, A.S.M.E.; H. C. Parmelee, chairman, Information Committee, E.C.P.D.; John P. H. Perry, director, A.S.C.E., and A. D. Flinn, director, Engineering Foundation. Dr. Isaiah Bowman, chairman, National Research Council, and president-

elect, The Johns Hopkins University, who was guest of honor, spoke of some of his engineering experiences.

E.C.P.D. Certification Program

WHO is an engineer, and by what right does he use that title or undertake to practice engineering? At present there is no single criterion by which an engineer's qualifications can be measured, either by his fellows or by the public that uses his services. The legal status of an engineer is determined in some states by a process of examination, registration and licensing. His educational status may be indicated by a college degree, and his technical qualifications by his grade of membership in a national society of high repute. Not all engineers are licensed. Neither do they all possess college degrees nor hold membership in a technical society. From the point of view of professional solidarity the situation is chaotic.

As part of its plan to enchance the professional status of the engineer, the Engineers' Council for Professional Development has undertaken to define minimum qualifications of education and experience, the fulfilment of which will entitle an engineer to be recognized as such among his fellows and in his relations with the public. E.C.P.D. is a conference of engineering bodies directly representing the professional, educational, technical, and legislative phases of an engineer's life. The participating bodies are the American Society of Civil Engineers, The American Society of Mechanical Engineers, American Institute of Electrical Engineers, American Institute of Mining and Metallurgical Engineers, American Institute of Chemical Engineers, Society for the Promotion of Engineering Education, and the National Council of State Boards of Engineering Examiners.

Through its Committee on Professional Recognition, on which the participating bodies are represented, E.C.P.D. has proposed a "minimum definition of an engineer," and a "program of certification into the profession." The definition of an engineer sets up minimum qualifications of technical education and practical experience, supported by examinations designed to establish the individual's ability to be placed in responsible charge of engineering work and to render him a valuable member of society. These proposals are now before the governing boards of the constituent bodies of E.C.P.D. When approved they will provide the criterion and the mechanism for professional recognition of engineers.

The program of certification into the profession was drafted by Dr. D. B. Steinman who represents the National Council of State Boards of Engineering Examiners on E.C.P.D. He is also a member of the Committee on Professional Recognition of which Conrad N. Lauer, president of the Philadelphia Gas Works, is chairman. The certification program recognizes the fact that the equivalent of a "grandfather clause" must be applied to permit automatic certification of those who are now recognized and accepted as engineers by legal authorities and by the profession. It also contemplates a reasonable transition period for the progressive adjustment of requirements and tightening of standards until the full program of E.C.P.D. for certification can be put into effect. Thus licensed engineers and certain members of technical societies will be automatically eligible to receive certificates according to a chronological plan up to January 1, 1938, at which time the formal certification will be put into effect. When that goal is reached it is hoped and expected that certification of an engineer by E.C.P.D. will set a minimum standard of professional training and experience by which he will be accepted and recognized among his fellows and in his relations with the public.

A.S.M.E. Committee Appointments

AT A meeting on May 20 of the Executive Committee of the Council of The American Society of Mechanical Engineers the following committee appointments and Society representatives were reported: Junior Advisor to Committee on Meetings and Program, David C. Cory, Jr.; Junior Advisor to Committee on Local Sections, Herbert A. McAninch; committee of American Foundrymen's Association for publication on alloy cast iron, Arthur Pletz; representative to Langley Field Conference, N.A.C.A., A. Klemin; representative to Fiftieth Anniversary, Brussels, June 13 to 15, of the Société Belge des Ingenieurs et des Industriels, Laurence V. Benét.

Tulsa Oil and Gas Power Meeting

A National Oil and Gas Power Meeting was held at Tulsa, May 8 to 11, under the joint auspices of the Mid-Continent Section and the Oil and Gas Power Division of The American Society of Mechanical Engineers. About 175 attended the four-day conference. The technical program, which was published in the May issue of MECHANICAL ENGINEERING, page 334, was slightly changed, as a paper by George Bays on Central Generating Plants was not presented, but in its place one by Joseph Niles on the Design of Portable Rotary Drilling Machines was substituted.

On the afternoon of May 8 after a discussion of the characteristics of Diesel fuel oil the meeting considered the pending legislation to place a tax of $1/2$ cent per gallon on all fuel oil. A resolution was passed protesting against such a Federal tax unless corresponding taxes, fully compensatory, be placed upon coal and upon power generated hydroelectrically, and upon any other fuel competing with Diesel fuel in Diesel engines, but not now taxed in proportion.

The meeting was noteworthy for the very excellent and lively discussion that followed practically every paper. The papers of the meeting were published, some in the May issue of *Diesel Power* and the others in the May 9 issue of the *Oil and Gas Journal*. Coordinated with the meeting was a small exhibit of Diesel-engine parts and accessories.

Mechanical Engineers' Day, San Diego, Calif., July 7

AT THE California-Pacific International Exposition, Balboa Park, San Diego, Calif., Sunday, July 7, 1935, has been designated as "Mechanical Engineers' Day." Members of the A.S.M.E. who plan to visit the Exposition early in July should bear this date in mind.

The American Society of Civil Engineers meets in Los Angeles, July 3 to 6, and its San Diego Section will be hosts at the Exposition to members and guests of that society on July 7, which has also been designated "American Society of Civil Engineers' Day."

C. H. Fellows Heads Boiler Feedwater Studies

AT A meeting of the Joint Research Committee on Boiler Feedwater Studies, on which The American Society of Mechanical Engineers is represented, held in Cincinnati on May 7, 1935, the resignation of S. T. Powell as chairman was announced. It was with considerable regret that the committee accepted the resignation of its chairman. It insisted, however, that Mr. Powell retain his membership on the committee and on its executive committee. He will continue also as a member of the Committees on Finance and Standardization of Water Analysis. The committee elected as its new chairman C. H. Fellows, Chemist of The Detroit Edison Company. R. C. Bardwell, Superintendent of Water Supply of the Chesapeake and Ohio Railway Company, was elected vice-chairman and the chairman was authorized to appoint a secretary.

A new subcommittee on important patents relating to boiler-feedwater treatment was stressed and the committee was organized. Mr. Powell agreed to accept the chairmanship of this subcommittee and stated that from time to time this committee would prepare for publication a list of the most important patents and reports on the recent developments in the treatment of boiler feedwaters.

S. F. Voorhees Heads Architects

STEPHEN F. Voorhees, member of the Committee on Publications of The American Society of Mechanical Engineers, has been elected president of the American Institute of Architects. Mr. Voorhees has been serving as chairman of the Construction Code Authority and is a member of the architectural firm of Voorhees, Gmelin, and Walker, of New York.

A.E.C. News From Washington

QUESTIONNAIRES have been mailed to 176,000 engineers for the survey of the profession by the U. S. Bureau of Labor Statistics in cooperation with Council and the engineering societies. July 6 is the closing date for receipt of blanks.

BUREAU OF LABOR SURVEY

This survey is not to be confused with the queries being sent by the Founder Societies and others so that jobless members may register for possible employment under the Federal work-relief program. The Labor Department survey goes to the entire profession, regardless of society membership. It is for every one, employed or unemployed. The blank can be filled out in a few minutes and mailed in the official envelope which requires no postage.

If you did not receive a blank, write Andrew Fraser, Jr., U. S. Bureau of Labor Statistics, Department of Labor, Washington, D. C. Act now so that the survey will be a success and the profession will have data on a broad base, the better to relate itself to present public problems.

The summary of the Brookings Institution reports, "America's Capacity to Produce" and "America's Capacity to Consume," furnished by courtesy of the Falk Foundation for distribution to engineers, has been in heavy demand. The American Engineering Council has secured a new supply of which a few still remain.

ENGINEERS IN PUBLIC AFFAIRS

Increased participation of engineers in public affairs is a theme upon which Council has been hammering for some time and one which is becoming more and more recognized as a need throughout the profession. At a meeting of the American Society of Municipal Engineers and the International Association of Public Works Officials in Washington last month, Dr. Louis Brownlow stated that engineers should begin to think of their relationship to the combination of cities *and* counties *and* states *and* the United States rather than to the cities *or* counties *or* states *or* the United States.

As reported previously, Council is working to this end through a plan which ultimately will result in the setting up of state and regional public affairs committees composed of key men in each area. A system of membership committees, now rapidly developing to encourage state and local societies to join Council under the new plan of nominal dues, is a step toward the final set-up.

In the preliminaries, there is one phase in which all can help. It is felt that, if engineers really are to bear weight in public affairs, the field must be developed along lines of engineering analysis just as the technique of the profession has taken form over the last several decades. We now have an extensive literature of engineering technique so that a specialist in any branch of the profession may read the record of successful experience in relation to his problems.

But the equally broad field of public affairs has not been fully explored and charted by engineers. Council, therefore, is seeking to assemble material in an effort to build up a record of practical experience along this vital line of activity. You can help by sending in your general observations as to the proper relationship of organized engineers to public affairs, together with accounts of actual cases with which you are familiar. How have engineering societies acted to support legislation in the public welfare? How have they helped promote sound public projects and improvements in public administration? How have they gotten their story over to the public so that the function and accomplishments of engineers have been recognized in their proper scale? The Council will appreciate having such material sent to it.

ACTIONS OF EXECUTIVE COMMITTEE

The Executive Committee meeting of Council in New York May 20 covered a wide field of subjects of basic interest to the profession. Reports of several of the Council's committees were accepted and steps were taken to effectuate the plans for membership, public affairs, activities, and special investigations which were brought forward at the annual meeting in January.

The Water Resources Committee report, prepared under the chairmanship of Wm. S. Conant, was approved. Two fundamental needs for the formation of a National Water-Resources Policy were expressed as: (1) Complete and correlated basic data bearing on the subject and (2) comprehensive study of water-control legislation. The report advocates the establishment of an interdepartmental Board of Water Resources Investigation to correlate the investigational functions of Federal agencies dealing with water resources. In connection with Federal reorganization plans, a Bureau of Water Resources is endorsed in principle.

Favorable comment was made on the collection and systematic arrangement of a large mass of information covered by the report of the Water Planning Committee. Extension of this work was recommended through a National Advisory Water Planning Agency for comprehensive integrated drainage-basin planning.

As to legislation, it is pointed out that many bills which are introduced in Congress have a tendency to stress the importance of water power beyond all the other urgent needs for water; also to overlook the known facts which limit the economic development of available power sites. Intensive study of proposed legislation by engineers is therefore deemed desirable.

Opposition to the establishment of additional river-basin authorities along the lines of TVA at the present time was adopted as a policy of Council.

Boards of Civil-Service Appeals, to settle differences between Federal civil-service employees and their superiors, are proposed in the Sirovich Bill (H.R. 3980). As the measure was first drafted, the representative of the employee on the three-man board set up to hear the case would have been a representative of the international union to which the employee belongs. But a revision permits the employee to choose his own agent so that technical societies may act in the case of an engineer. The other two members of a board would represent the Civil Service Commission and the Federal department or agency involved.

Cases where engineers who have qualified under civil service and feel that the rating did not give them the guarantee of employment to which they are entitled are being studied. Arthur W. Berresford, past-president of the Council, has started his preliminary study of the general subject of the relation of engineers to the U. S. Civil Service.

R. E. W. Harrison, chief of the Machinery Division, U. S. Bureau of Foreign and Domestic Commerce, member, A.S.M.E., points out the need for engineering societies to draft a program which will serve to coordinate engineering thought in respect to problems of national scope confronting the durable-goods industries. He suggests the Council as the logical organization to provide executive direction toward such a program.

The Council's support of a program of aviation research under the National Advisory Committee for Aeronautics was recommended by the A.E.C. Committee on Aeronautics (Grover C. Loening, chairman) and was approved by the Executive Committee. The desired program is set forth in a paper by Alexander Klemin, secretary of the A.E.C. Committee. Copies are available on request. Briefly, the recommendation is that the N.A.C.A. receive $50,000 per year of Federal funds earmarked for research to be done by universities and other institutions of public standing; not for educational purposes, buildings, or basic equipment. Scientific workers of approved institutions desiring to do research would submit formal plans. Results would be published in the form of N.A.C.A. technical notes or technical reports. A committee representing the N.A.C.A., Navy, Army, and Department of Commerce would supervise.

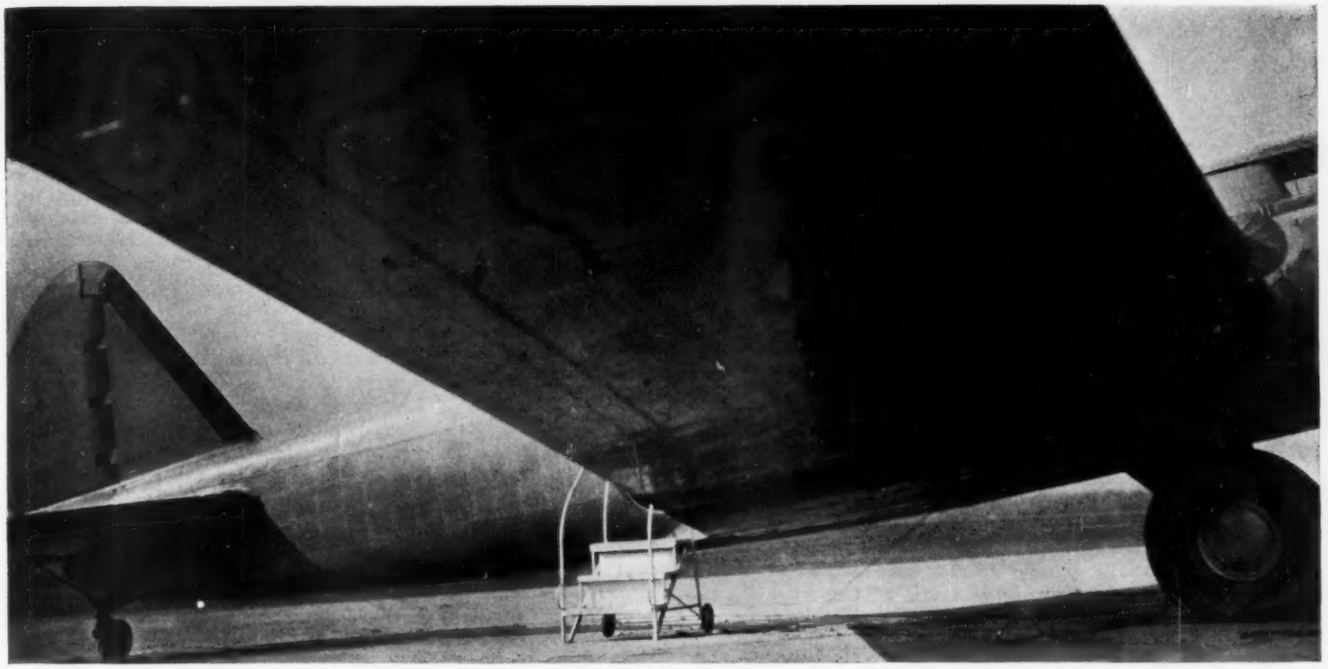
EFFECT OF THE SUPREME COURT DECISION ON GOVERNMENT CONSTRUCTION PROGRAMS

Administrators of Government funds of the several agencies of Government are scrutinizing with renewed care the exact phraseology of the legislation which gives them their authority. One immediate effect, therefore, of the hundreds which flow from this historic decision is to call attention both on the part of those who administer the work-relief program and those who are expected to benefit by the work-relief program, to its exact provisions. This redefining of authority now taking place is further affected by the interrelations between state law and Federal law on relief. This situation tends for further confusion in straightening out the organization and expenditure of the work-relief program.

The general status of the work-relief measure have been noted in previous issues of MECHANICAL ENGINEERING and the amounts of the work relief appropriations have been given. Because of the confusion that exists both outside and inside of Washington at the moment, it seems worth while to restate the fundamental philosophy and purpose of the work-relief bill for the benefit of engineers and engineering:

(*a*) This bill was conceived and passed to provide funds to employ for one year 3,500,000 heads of families now on relief. It was conceived as a relief measure primarily and not as an employment measure. The four billion dollars was established on the basis of actually averaging to pay a man on relief $50 a month. This sum is the approximate average allowance per head of a family of from $19 to $94 a

(*Continued on page 464*)



IF WEAR IS A WORRY - REMEMBER

RUBBER

Reading time 62 seconds

HIGH-SPEED AIRPLANES created a new problem in abrasion. Whirling propellers picked up small stones, cinders and sand particles as planes were taking off, threw them with tremendous force against the tail surfaces, especially the leading edges, sometimes even wings. Double and triple thicknesses of metal were tried without success. Then someone thought of Goodrich—and now practically every modern transport carries Goodrich "abrasion shoes"—strips of a special kind of rubber protecting the points where most wear occurs. Many of them have been in service for a year and a half. Former repair costs and delays have been forgotten.

Airplanes may be a far cry from your business, but rubber is not. Whatever you make or do, chances are that rubber in its new compounds developed by Goodrich can cut costs, increase precision, reduce waste, add new sales advantages.

Goodrich engineers have led in perfecting rubber compounds until today rubber by Goodrich can be bonded inseparably to metal; it can be made odorless, tasteless; it can be in brilliant colors, intricate forms, unusual textures; it can resist chemicals, heat, cold, oil; it can flex millions of times without breaking; it can outwear the hardest wood, the toughest metal.

Rubber as compounded by Goodrich is on the march to new usefulness in industry. Investigate its possibilities in your own. The B. F. Goodrich Co., Mechanical Rubber Goods Division, Akron, Ohio.

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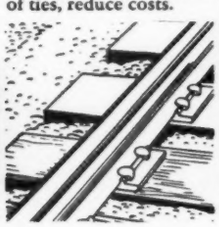
ALL *products* *problems* IN RUBBER

Rubber linings, made for ball mills by Goodrich, withstand terrific abrasion of steel balls and mineral ore, outwear 3-inch manganese-steel liners, increase efficiency.

Goodrich rubber cushions under railroad tie plates withstand the constant chafing of heavy metal. They last indefinitely, prolong life of ties, reduce costs.



Goodrich drilling hose for oil wells withstands the abrasion of tons of mud at 800 pounds pressure, lasts as long as steel hose formerly used, costs one-half as much.

"Armorite"—a special rubber made by Goodrich for lining chutes handling abrasive gravel—has been known to last 10 times as long as the steel formerly used.

Goodrich cooperated with another manufacturer in the development of a safety stair tread, which outwears granite and reduces accidents from slipping.

Sand blasting wore out steel helmets in a few hours. Now the helmets are covered with rubber by Goodrich, using a special process—and they last for months.

month. This compensation for relief was purposely set at this relatively low figure so that men on relief would prefer jobs outside of relief, rather than to continue on types of work paid on a relief basis.

(*b*) The bill provides that this work shall be carried out within the locality of a man's present place of residence. In other words, local projects of such character that lend themselves to relief work would employ men and women on local relief rolls.

(*c*) The type of any given project is to be determined by the training and experience with the available relief labor within the locality of that project.

(*d*) This whole program is predicted on the intention that work relief shall be made unattractive.

(*e*) The bill includes provisions for administration expenses. The payment for such administration expenses is *not* on the basis of the relief compensation, but is to be established on the basis of the going local rates or fees for such work.

American Engineering Council has followed this program from its beginning. The staff of Council is familiar with the details of the program from its inception. The summary in the long view represents the understanding not from newspaper comment, but from an analysis of the law itself and of the Executive Orders so far issued.

Industrial Relations Conference, Silver Bay on Lake George, August 28–31

ANNOUNCEMENT has been made of the Eighteenth Annual Conference on Industrial Relations to be held August 28 to 31, at Silver Bay on Lake George, N. Y., under the auspices of the Industrial Department of the National Council of Y.M.C.A.'s, 347 Madison Ave., New York, N. Y. The topics to be discussed are collective bargaining, social security, employee training, wage incentives, and general problems relating to the revaluation of personnel programs.

The Shipping, Engineering, and Machinery Exhibition, London, Sept. 12–28

ANNOUNCEMENT has been received of The Shipping, Engineering, and Machinery Exhibition, incorporating the Foundry Trades Exhibition, to be held at Olympia, London, England, September 12 to 28, 1935, under the patronage of the British Engineers' Association, Inc., the Society of Motor Manufacturers and Traders, Ltd., the British Marine Oil Engine Manufacturers and Traders, Ltd., the British Marine Oil Engine Manufacturers' Association, and the Foundry Trades' Equipment and Supplies Association, Ltd. This is the thirteenth of a series of exhibitions that have been held biennially (except during the War) since 1906.

The exhibition is devoted to shipping, shipbuilding, marine engineering, dock and harbor equipment, internal-combustion engines, iron and steel, welding and welding equipment, production engineering, foundry plant, equipment and supplies, drafting-room equipment, nautical and scientific instruments, and marine accessories.

Third National Machine Tool Congress

THE Third National Machine Tool Congress will be held in Cleveland from September 11 to 21. The A.S.M.E. Machine Shop Practice Division and Cleveland Local Section will sponsor the evening sessions on September 11 and 12. Other evening sessions will be sponsored by the Society of Automotive Engineers and the American Society of Tool Engineers. The National Machine Tool Exposition under the auspices of the National Machine Tool Builders Association will run simultaneously with the Congress.

A.S.T.M. Officers for 1935-1936

OFFICERS of the American Society for Testing Materials for 1935-1936 are as follows: President, H. S. Vassar, Public Service Elec. & Gas Co., Irvington, N. J., member, A.S.M.E.; vice-president, A. E. White, director, Department of Engineering Research, University of Michigan, Ann Arbor, Mich., member, A.S.M.E.; members of executive committee, W. H. Graves, chief metallurgist, Packard Motor Car Co., Detroit, Mich.; R. L. Hallett, National Lead Co., Brooklyn, N. Y.; N. L. Mochel, metallurgical engineer, Westinghouse Elec. & Mfg. Co., Philadelphia, Pa.; H. H. Morgan, manager, Rail and Track Fastenings Dept., Robert W. Hunt Co., Chicago, Ill., member, A.S.M.E.; and W. R. Webster, chairman of the board, Bridgeport Brass Co., Bridgeport, Conn., member, A.S.M.E.

Engineering Index National Committee to Solicit Funds

ORGANIZATION of the Engineering Index National Committee is now sufficiently near completion to begin the actual solicitation of funds, according to the announcement of its chairman, Dr. Frank B. Jewett, president of Bell Telephone Laboratories, Inc., and vice-president of the American Telephone and Telegraph Corporation.

With regional subcommittees, the group includes more than 125 representative engineers, educators, and industrialists in various sections of the country. These members will approach, in the next few months, several hundred leading industrial corporations in New York, Boston, Philadelphia, Pittsburgh, Cleveland, and Chicago.

The keynote of the campaign is sounded by Dean Collins P. Bliss, of the College of Engineering of New York University, who is president of the Index.

"The primary purpose of the fund we are about to raise," he explains, "is to set in motion a progressive constructive program. Of the value of the Engineering Index to science and education there can be no question, but it is of even greater value to American industry. The Index is more than an up-to-date record of industrial progress; it is a fountainhead of information which industry must always have available.

"Inasmuch as industry benefits so greatly and so directly from the Index, the obligation of keeping the Index going rests squarely upon industry's shoulders. Hence it is among industrialists that the present campaign is being conducted.

"The program which the fund will make possible will be carried out over a five-year period. Not only will the continued usefulness of the Index be insured for that period, but by the end of that time it will have become wholly self-supporting. And, what is equally important, the Index will have been extended to an ever-widening circle of users through a reduction of the subscription rates until the rates have become only about half what they are now.

"Some question may be raised as to the wisdom of making an appeal for funds at a time when economic conditions seem as unfavorable as they are at present. The existing poor business conditions, however, are one of the chief reasons for action. The Index always has been valuable; today it is necessary.

"Right now industry is looking to the engineer to lead the way out of the depression. Every manufacturer must have new processes, new methods, new equipment, new products, if he is to keep pace with the upward climb. It is essential that each be thoroughly conversant with what the others are doing."

The Engineering Index, for which the fund is being raised, is unique in its field. It may be described as a virtually complete catalog, with annotations, of current technical literature in all branches of engineering.

It is published in two forms: The complete annual volume and the cumulative daily and weekly card service, including 280 subdivisions. Altogether about 2000 publications from 40 countries and in 20 languages are reviewed by the editors.

Among the industrialists, educators, and engineers now enlisted in the enterprise are: Dr. John V. N. Dorr, president of The Dorr Company, National Vice-Chairman; Joseph W. Barker, dean of the Engineering School, Columbia University, New York area chairman; Irving E. Moultrop, chief engineer, Edison Electric Illuminating Company of Boston, chairman of the Boston area committee; Parke R. Kolbe, president, Drexel Institute, Philadelphia area chairman; Samuel M. Kintner, vice-president in charge of research, Westinghouse Electric and Manufacturing Company, chairman of the Pittsburgh area committee; and W. B. Mayo, chairman of the Detroit area committee. In Cleveland a committee is being sponsored by James H. Herron of the James H. Herron Company; and William L. Abbott, Chief Engineer, Commonwealth Edison Company, is serving as area chairman in Chicago.

(*Continued on page 466*)

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A. C. or D. C. Motor Drive
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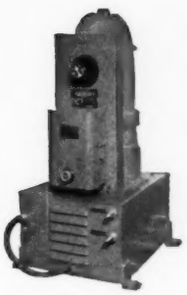

"Stable-Arc" Welders
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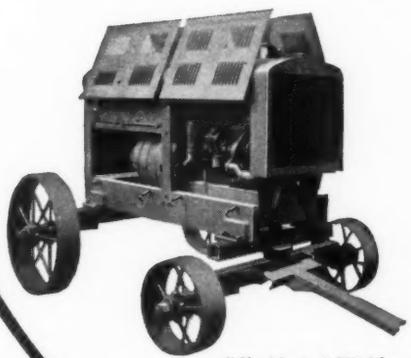
75 and 100 amps.

"Shield-Arc AC" Welders
A. C. Motor Drive



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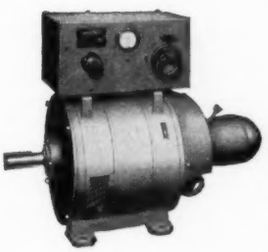

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To be sure you get all the advantages arc welding can offer you, consult The Lincoln Electric Company, Cleveland, Ohio. Largest Manufacturers of Arc Welding Equipment in the World.

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POP "Lincoln is just as interested in us as before we bought their equipment. Here's their suggestion for redesign which will cut our costs 17%."

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include electrode holders, cable, face and head shields, lens and cover glass, protective clothing, cleaning tools, tables and booths, and manipulators.

B. M. Brigman Honored

B. M. BRIGMAN, Manager, The American Society of Mechanical Engineers, and dean, Speed Scientific School, University of Louisville, has been appointed a member of the City Planning and Zoning Commission, by Mayor Neville Miller, of Louisville, Ky.

American Foundrymen's Association, Toronto, Aug. 20–23

THE 1935 convention of the American Foundrymen's Association will be held in Toronto, August 20 to 23, with headquarters at the Royal York Hotel.

The schedule of technical sessions, shop-operation course meetings, and round-table luncheons, developed by the various division program committees, will provide papers, reports, and discussions of current problems relating to executive, metallurgical, engineering, and production phases. Sessions have been planned on silicosis and employer responsibilities, safety codes and dust-collection equipment, materials-handling equipment problems for handling molds and sand in the smaller or medium-sized foundries, and apprentice training.

Two symposia are to be held, one on "Deoxidation and Degasification of Nonferrous Casting Alloys," and the other on "Centrifugal Castings."

Cooperative Mechanical Engineering Course at M.I.T.

A NEW five-year cooperative course in mechanical engineering, leading to the degree of master of science, at the Massachusetts Institute of Technology has been announced.

The new course, which is designed to give students an insight into the technical and executive aspects of industrial manufacture, will be given in cooperation with the General Electric Company. Under the cooperative plan, which is similar to that successfully operated for several years past by the department of electrical engineering, students will carry on practical work in the company's plants in conjunction with their studies at the Institute.

The industrial work has been carefully planned with a view to its educational value, and at all times will be closely correlated with instruction at Technology. The content of the first four years of the course will be essentially the same as that given in the present course in mechanical engineering, there being no omissions in the fundamental and professional subjects. Those subjects omitted from the regular-course curriculum have their counterparts in the program at the works. The final year of graduate study and research will be planned for each student in accordance with the requirements of the graduate school. During the final term students may be assigned to the company's research departments for special work designed to develop individual aptitudes.

Students will be chosen for the new option on the basis of aptitude and scholastic records after two years' study in the regular mechanical-engineering course. The subsequent three years, including summers, will be spent either at Technology or at the industrial plants. The course will lead to the degree of master of science, together with the degree of bachelor of science as of the preceding year.

A.S.M.E. Transactions for June, 1935

THE June, 1935, issue of the Transactions of the A.S.M.E., the *Journal of Applied Mechanics*, contains the following papers:

TECHNICAL PAPERS

Distributed Gravity and Temperature Loading in Two-Dimensional Elasticity Replaced by Boundary Pressures and Dislocations, by M. A. Biot. (Discussion will be received on this paper until August 10, 1935.)

On the Hydrodynamic Analogy of Torsion, by J. P. Den Hartog and J. G. McGivern. (Discussion will be received on this paper until August 10, 1935.)

Pitting Due to Rolling Contact, by Stewart Way. (Discussion will be received on this paper until August 10, 1935.)

Film Lubrication in Sleeve Bearings, by M. Stone. (Discussion will be received on this paper until August 10, 1935.)

RESEARCH REVIEWS

Review of Recent Research in Thermodynamics, by John A. Goff

DESIGN DATA

Factors of Stress Concentration Photoelastically Determined, by Max M. Frocht

DISCUSSION

On previously published paper by Messrs. R. E. Peterson and A. M. Wahl

BOOK REVIEWS

By L. C. Maugh, C. H. Jennings, J. N. Goodier, J. Ormondroyd, S. Kleinhans, J. C. Hunsaker, and J. P. Den Hartog.

Candidates for Membership in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after July 25, 1935, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member having comments or objections should write to the secretary of the A.S.M.E. at once.

NEW APPLICATIONS

ALEXANDER, RALPH M., Prospect Park, Pa.
ANDREWS, ROBERT MILLS, Ithaca, N. Y.
ANTHONY, RICHARD L., Hamden, Conn. (Rt)
BASSOFF, A. BAIR, New York, N. Y. (Rt & T)
BOCKSTAHLER, L. A., JR., Shaker Heights, Ohio (Re)
CARROLL, W. M., Fort Wayne, Ind.
CRONVICH, JAMES A., New Orleans, La. (Prize Student)
COOMBS, ROBERT R., Toronto, Ohio
DOLGORUKOV, GREGORY S., New York, N. Y.
FAXON, H. C., Singapore, S. S.
FRY, PEN W., Seattle, Wash.
GRAHAM, E. H., JR., Hyde Park, Mass.
HARVEY, KENNETH H., Glens Falls, N. Y.
INGLISH, HAROLD C., East Hartford, Conn.
KEMMISH, L. W., Pullman, Wash.
LACHNICHT, GEORGE H., JR., Brooklyn, N. Y.
LEESON, MELDON G., Lincoln, Nebr.
MATHUR, RAM KISHAN, Punjab, India
MESWARP, HERMAN W., Brooklyn, N. Y.
MICKLETHWAITE, WM. E., Toronto, Ont., Can.
NEWELL, JOHN B., Seminole, Okla.
SAILER, JOSEPH, JR., Philadelphia, Pa.
SCHEUNEMAN, ALBERT, Buffalo, N. Y.
SCHUSTER, ARTHUR W., Buffalo, N. Y.
SHUMAN, LLOYD E., Seattle, Wash.
SINGH, JAGIR, Punjab, India
SMITH, YOUNG C., Detroit, Mich.
SPARK, OLIVER S., Lakewood, Ohio
UGRIN, NICK, Los Angeles, Calif.
VAN DONGEN, J. R. J., Eindhoven, Holland
WALTERS, PROF. J. E., Lafayette, Ind.

CHANGE OF GRADING

Transfers from Associate-Member

CLARK, ERNEST E., Brooklyn, N. Y.
HOOK, JAMES W., New Haven, Conn.
ROMANACH, JUAN A., Havana, Cuba
WALES, C. CLARKE, Cleveland, Ohio

Transfers from Junior

COLE, KENNETH W., Chicago, Ill.
DANNETTEL, R. C., Baltimore, Md.
FARMER, EDWARD H., Toledo, Ohio
HINE, RUSSELL C., Baltimore, Md.
FORMAN, W. W., Waterbury, Conn.
HOEY, CLYDE R., JR., Canton, N. C.
KRATSCH, A. E., Manitowoc, Wis.
KRAUS, CHARLES E., Ann Arbor, Mich.
MATTSON, ARNE L., Tammerfors, Finland
RYAN, WILLIAM J., New York, N. Y.
SMITH, RONALD R., Ft. Atkinson, Wis.
THOMPSON, MILTON J., Ann Arbor, Mich.
WRIGHT, DONALD M., Cambridge, Mass.

Necrology

THE following deaths of members have recently been reported to the Office of the Society:

BILGER, HENRY E., April 23, 1935
CLAYS, ERNEST M., April 10, 1935
COLLINS, THOMAS F., JR., May 14, 1935
CORNMAN, L. M., February 20, 1935
FRY, GEORGE C., May 5, 1935
HAMMER, ALFRED E., May 9, 1935
HEATH, GEORGE E., March 18, 1935
HENDERSON, JOHN V., March 4, 1935
HISS, REINHARD A., February 17, 1935
LUDEMAN, EDWIN H., November 6, 1934
MELVILLE, MAINOR STUART, April 25, 1935
MERRILL, ALBERT S., March 31, 1935
NAEGELEY, JOHN C., April 6, 1935
NOLDE, FRED, December 19, 1934
PARCE, J. Y., JR., April 18, 1935
REID, WILLIAM L., March 9, 1935
SKOGMARK, JOHN, March 26, 1935
STEPHEN, CHARLES W., May 2, 1935
STEWART, JAMES D., JR., April 26, 1935
WRIGHT, ANTON P., JR., March 28, 1935